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GEOGRAPHIC VARIATION IN THE MOUSE *PEROMYSCUS DIFFICILIS*

BY DONALD F. HOFFMEISTER AND LUIS DE LA TORRE

ABSTRACT: Two species of *Peromyscus*—*P. difficilis* and *P. nasutus*—have been regarded by some authors as conspecific because of resemblances in morphological features and complementary geographical ranges. Specimens from new, critical localities, particularly southeastern Arizona, provide additional evidence bridging the gap between the two "species." These together with many of the other specimens from throughout the range—Colorado to Oaxaca—have made possible a more complete taxonomic reevaluation. Most of the 14 morphological features vary in a clinal fashion. This is best shown for length of head–body, tail, hind foot, ear, toothrow, and breadth of braincase. Where the clines are not continuous, the interruptions usually demark the limits of subspecies. We conclude that there is one species, *Peromyscus difficilis* (J. A. Allen) 1891, with *Peromyscus nasutus* (J. A. Allen) 1891 as a synonym. As defined, the species consists of eight subspecies.

Fifty years ago, Wilfred H. Osgood grouped five species of *Peromyscus*—*truei, nasutus, polius, bullatus* and *difficilis*—in a so-called "*truei*-group." These species, with the exception of *polius,* seem closely related. The specific status of *truei, bullatus* and *nasutus,* together with the more recently described *comanche,* has been discussed previously by Hoffmeister (1951: 22–26). As regards *nasutus* and *difficilis,* there has been some question as to whether these are distinct species. Osgood, himself, queried this (1909: 177, 180). Certain populations of *P. difficilis* from the northern part of the Sierra Madre Occidental (the northern part of the range as previously understood) possess characteristics that approach those of *nasutus.* However, there was a large hiatus between the range of *difficilis* and *nasutus.* Specimens from the Chiricahua Mountains, southeastern Arizona, recently acquired by our museum and by the American Museum, bridge the characteristics between the northern populations, nominal species *nasutus,* and the southern populations, nominal species *difficilis.* Study of this material in conjunction with that from northern and southern localities indicates that the differences between *nasutus* and *difficilis* are intraspecific clinal variations and not specific differences.

Acknowledgments.—At the outset of this study, we discovered that George Goodwin of the American Museum was interested in identifying certain critical

specimens from the Chiricahua Mountains. He surmised that these specimens might be *Peromyscus difficilis*, and he most kindly turned them over to us to augment our samples. We are most appreciative.

For the loan of specimens and for many courtesies shown, we would like to thank George C. Goodwin and Richard G. Van Gelder, American Museum of Natural History (AM); the late Wilfred H. Osgood and Colin C. Sanborn, Chicago Natural History Museum (CM); Sydney Anderson and E. Raymond Hall, Museum of Natural History, University of Kansas (KU); George Lowery, Museum of Zoology, Louisiana State University (LSU); Seth B. Benson, University of California Museum of Vertebrate Zoology (MVZ); W. F. Blair, University of Texas (TU); William H. Burt, University of Michigan, Museum of Zoology (UM); Stanley P. Young, U.S. Fish and Wildlife Service, Bird and Mammal Laboratories (USBS). The Graduate College of the University of Illinois helped materially by financially supporting part of this study. The art work accompanying this paper has been executed by Harry C. Henriksen and Manuel Hernandez of the Museum of Natural History, University of Illinois.

METHODS

We have not attempted to examine every available specimen of each subspecies. Most of the specimens from areas we judge to be critical, and from many other places, have been examined. Some of the specimens were examined at a much earlier date by Hoffmeister only. Skull measurements are taken as explained by Hoffmeister (1951: 28). Those animals called adult have the major cusps of the molar teeth worn smooth, at least on the lingual side of the upper teeth. Unless otherwise indicated, all measurements are in millimeters. Measurements are given in a telegraphic style for external and cranial features. The order is as follows: *external*—total length, tail, hind foot, ear from notch (dry); *cranial*—greatest length of skull, basilar length, greatest breadth of braincase, interorbital constriction, length of nasals, shelf of bony palate, palatine slits, diastema, post-palatal length, alveolar length of maxillary toothrow.

THE NASUTUS-DIFFICILIS COMPLEX

Peromyscus nasutus has been characterized as a species with large ears, large bullae, and tail longer than the head and body. *Peromyscus difficilis* was considered to differ from *nasutus* in larger size, especially longer feet and tail, and in larger skull. From various localities (Fig. 1, "Localities") throughout the range of *nasutus* and *difficilis*, we have plotted the average measurement for each character on a master map. Some of these are shown in their geographic relationships in Figs. 1–2. The change in each character usually is of a gradual or clinal nature. The character is usually smallest in the north, largest in the south. The changes that occur are those to be expected between populations of one species and not between two species.

Thus, we are of the opinion that *nasutus* and *difficilis* are conspecific. The nominal units are regarded as geographical races of the one species *Peromyscus difficilis*. The name *difficilis* was chosen since *Vesperimus difficilis* Allen, 1891, has page priority over *Vesperimus nasutus* Allen, 1891.

Characters showing well-marked clinical variations are length of head–body, tail, hind foot, ear, and toothrow, and breadth of braincase. We do not imply that in all cases there is a continuous cline from the northernmost to the southernmost populations. Some clines become interrupted and the direction of change altered. These interruptions delimit the populations which we have interpreted as subspecies. As an example, hind feet are shortest in the north, longest in the south. However, there are numerous interruptions in the cline and many of these represent subspecific "changes."

Some characters showing less-marked or no clinal variation include greatest length of skull, length of nasals, diastema, palate, palatine slits, and breadth through interorbital region. These characters vary more between populations than in an over-all geographical fashion.

In general, there is a clinal change in color from the lightest at the north to the darkest at the south (Fig. 2, "Color intensity"). This is well exemplified by the light-colored animals from Colorado and New Mexico and the dark-colored specimens of the race *felipensis* from Oaxaca. Along the color clines there are certain changes which are more abrupt than at other places.

The change between the Sierra del Pino (**s**), northern Coahuila, and the vicinity of Santa Teresa (**r**), central Coahuila, is marked. The change is of about the same magnitude as that between specimens from the Chiricahua Mountains (**c**), southeastern Arizona, and the vicinity of Batopilas (**d**), Chihuahua. Specimens from the vicinity of San Antonio (**q**), southern Coahuila, and from the vicinity of El Salto and La Ciudad (**g**), Durango, are nearly as dark as those from further south, even as far south as Puebla and Tlaxcala. However, most specimens of *amplus* have, in addition to the dark color, an ochraceous undertone. Specimens from localities in Querétaro and Hidalgo, namely Cadereyta and San Agustín, are less dark and show much of the ochraceous color without the dark overlay.

Peromyscus difficilis (J. A. Allen)

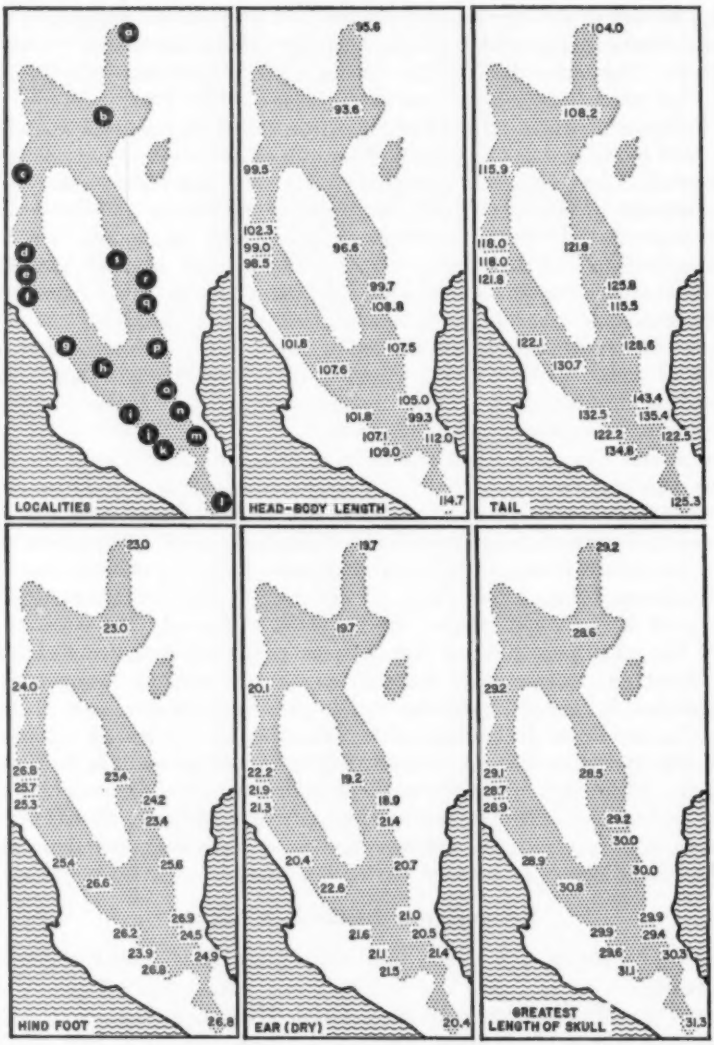
Vesperimus difficilis J. A. Allen, 1891, Bull. Amer. Mus. Nat. Hist., 3: 298, June 30.

Peromyscus difficilis, Trouessart, 1897, Catal. Mamm., p. 518.

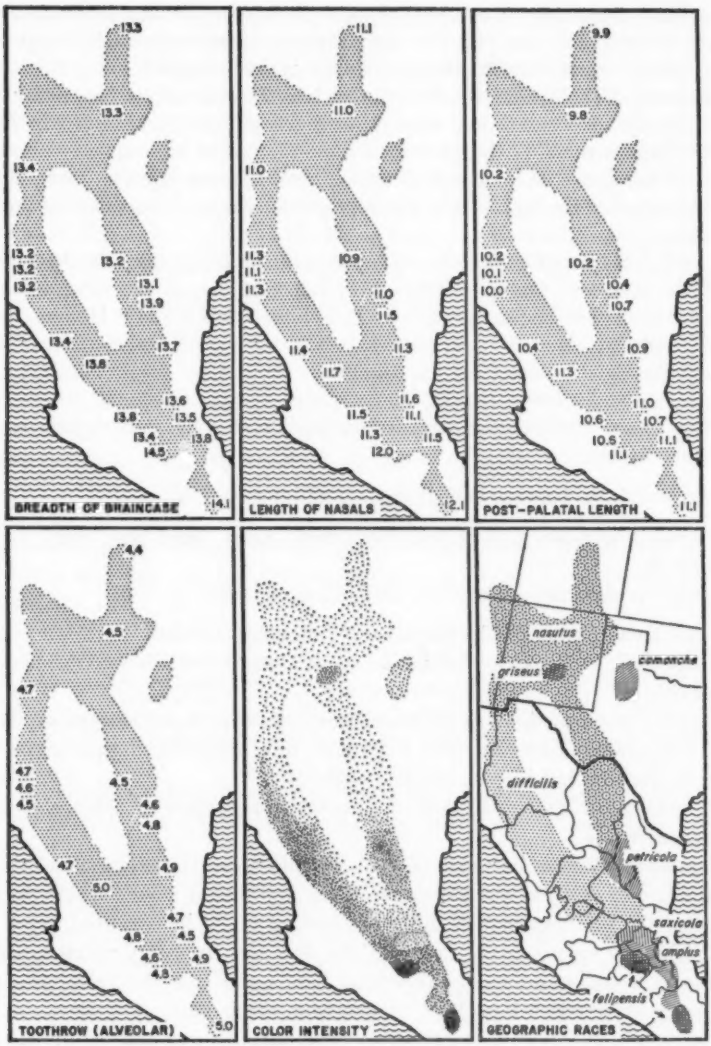
Vesperimus nasutus J. A. Allen, 1891, Bull. Amer. Mus. Nat. Hist., 3: 299, June 30.

Range.—From north-central Colorado to central Oaxaca, mostly in the Rockies and Sierra Madre and adjacent ranges, as indicated in Fig. 2 ("Geographic races").

Diagnosis.—A species of *Peromyscus* characterized by large ears (17.5–23.0, dry); ears shorter (dry) than hind foot; evenly bicolored tail, which is longer



FIGS. 1–2.—Maps showing geographic variation of selected characters of *Peromyscus difficilis*. In map of localities, the numbers refer to specimens from the following general localities (the number of specimens averaged is indicated in parentheses): **a**, Owl Canyon, Colo. (5); **b**, vicinity of Santa Fe, New Mexico (5); **c**, Chiricahua Mts., Ariz. (15); **d**, 65 mi. E Batopilas, Chih. (3); **e**, La Unión, Chih. (18); **f**, near Guadalupe y Calvo, Chih. (4); **g**, El Salto and near La Ciudad, Dgo. (8); **h**, Sierra de Valparaiso, Zac. (9); **i**, Santa Rosa,



Gto. (10); **j**, Atlacomulco, Méx. (14); **k**, Contreras, D. F. (6); **l**, Cerro San Felipe, Oax. (4); **m**, near Tlaxcala, Tlax. (8); **n**, Cadereyta, Querétaro, and Hidalgo: Zimapán, Ixmiquilpán, San Agustín (19); **o**, Encarnación, Hgo. (5); **p**, Miquihuana, Tamps. (7); **q**, near San Antonio de las Alazanas, Coah. (7); **r**, vic. Santa Teresa, Coah. (6); **s**, Sierra del Pino and vic. Ocampo, Coah. (7).

than head and body (in adults, always more than 90 but less than 150); medium-sized hind foot (22–27); long rostrum (nasals about 11); large auditory bullae; supraorbital border not beaded or sharp-angled.

Remarks.—The species *P. difficilis* as here delimited is a member of the "*truei*-group" of Osgood and consists of eight subspecies. As seen in Fig. 2 ("Geographic races"), the greatest differentiation of the species has taken place in the dissected highlands of central and southern México. Little change has taken place throughout the physiographically more homogeneous parts of its range.

In many features *Peromyscus polius* Osgood shows approach to the *nasutus-difficilis* complex. Osgood (1909: 177) felt that one of the most trenchant characters of the species was the whitish-colored tarsal joint. Hooper (1955: 18) found this character not diagnostic, and we would agree. To us, *polius* is importantly different from the species *P. difficilis*, as now defined, in possessing markedly longer nasals, longer palate, longer diastema, shorter ears, slightly longer toothrow, slightly longer head and body, and slightly smaller auditory bullae.

Peromyscus difficilis difficilis (J. A. Allen)

Vesperimus difficilis J. A. Allen, 1891, Bull. Amer. Mus. Nat. Hist., 3: 298, June 30.

Peromyscus difficilis, Trouessart, 1897, Catal. Mamm., p. 518.

Type locality.—Sierra de Valparaiso, Zacatecas, México.

Range.—From western Chihuahua, south along Sierra Madre Occidental to Guanajuato.

Diagnosis.—A medium-sized race, intermediate in most measurements between *nasutus* and *amplus*, with large hind foot; relatively dark in color with little ochraceous but heavily overlaid with black.

Comparisons.—Differs from *P. d. amplus* by reduction of ochraceous color and smaller size.

Remarks.—Within the range of *P. d. difficilis* there is marked clinal change from north to south in many characteristics. Specimens from the type locality are near the southern part of the range and, as might be expected, are larger than what we regard as the "average" for *difficilis*. Probably specimens from Durango would more nearly represent the "mean" for the race. In color, topotypes show much less clinal change from the mean.

The race *difficilis* is distinguishable from *saxicola* and *amplus* by the rich ochraceous color which is broken on the dorsum by a median band of black.

Specimens from western and southern San Luis Potosí are from an area intermediate geographically between *difficilis*, *petricola* and *saxicola*. These specimens are also intermediate morphologically. However, they appear to be closer to *difficilis* than to the other two races. Those from southern San Luis Potosí (San Isidro) approach *saxicola* in their brownish-red color. Those from

western San Luis Potosí (Cerro Peñon Blanco) show some approach toward *petricola*, but have a distinctive pale color.

Measurements.—Twelve males, 13 females, adults, from vicinity of Batopilas, La Unión, and Guadalupe y Calvo: *external*—219.2, 119.3, 25.9, 21.8; *cranial*—28.9, 21.8, 13.2, 4.5, 11.2, 4.3, 6.2, 7.5, 10.1, 4.6.

Specimens examined.—Total, 82. CHIHUAHUA: 65 mi. E Batopilas, 4 (USBS); La Unión, 18 (MVZ); near Guadalupe y Calvo, 11 (USBS). DURANGO: El Salto, 5 (USBS); 11½ mi. E La Ciudad, 4 (UI). ZACATECAS: Sierra de Valparaiso, 10 (USBS). GUANAJUATO: Santa Rosa, 10 (USBS). SAN LUIS POTOSÍ: Cerro Peñon Blanco, 7,750 ft., 6 (LSU); 3 km. SW San Isidro, 14 (LSU).

Peromyscus difficilis nasutus (J. A. Allen)

Vesperimus nasutus J. A. Allen, 1891, Bull. Amer. Mus. Nat. Hist., 3: 299, June 30.

[*Peromyscus truei nasutus*], Trouessart, 1897, Catal. Mamm., p. 517.

Peromyscus nasutus, Osgood, 1909, N. Amer. Fauna, 28: 176, April 17.

Type locality.—Estes Park, Larimer County, Colorado.

Range.—From north-central Colorado southeastward through the Mesa de Maya of the panhandle of Oklahoma, elevated portions of eastern New Mexico, to the Sierra de San Marcos in Coahuila, and southwestward to Navajo Mountain, Utah, and along the easternmost part of Arizona, at least to the Chiricahua Mountains.

Diagnosis.—A race of *Peromyscus difficilis* characterized by pale coloration (one of the palest races of the species); ochraceous or tawny color of back and sides only lightly overlaid with black; dorsal tail stripe brownish or brownish black; size small, but showing marked clinal variation, being smallest in north, largest in south; hind foot usually less than 24.5; skull small, with short toothrow.

Comparisons.—Differs from *P. d. difficilis* in lighter coloration; smaller size, but in Chihuahua and Coahuila, broad zone of intergradation in size; smaller hind foot; smaller ear.

Remarks.—Throughout its wide range, *P. d. nasutus* shows considerable variation, but much of this is clinal (see Figs. 1–2). Specimens from southern Chihuahua (Batopilas, La Unión, and Guadalupe y Calvo) are intermediate in many features between *nasutus* and *difficilis*. On the basis of darker color, larger hind feet, and in large size they are referred to *difficilis*. Specimens from the Sierra del Pino and Sierra de San Marcos of Coahuila possess many features intermediate between *nasutus*, *difficilis* and *petricola*. On the basis of color and size, we refer them to *nasutus*.

Measurements.—Two males, three females from Owl Canyon, Larimer County, Colorado: *external*—200.6, 104.0, 23.0, 19.7; *cranial*—29.2, 21.2, 13.3, 4.5, 11.1, 4.3, 5.9, 7.4, 9.9, 4.4.

Specimens examined.—Total, 340. COLORADO: *Larimer Co.*, Owl Canyon, 11 (UI); Bingham Hill, 6 mi. NW Ft. Collins, 2 (UI); Estes Park, 7 (USBS);

Boulder Co., Boulder, 12 (CM); *El Paso Co.*, 3 mi. N Colorado Springs, 6,000 ft., 3 (AM); Gold Hill, 9 (USBS); *Fremont Co.*, Cañon City, 1 (USBS); *Las Animas Co.*, Trinidad, 9 (USBS). OKLAHOMA: *Cimarron Co.*, 3 mi. N Kenton, 1 (UM); 4 mi. N Kenton, 1 (UI); Taft Canyon, Black Mesa, 1 (UM). NEW MEXICO: *Rio Arriba Co.*, Cieneguilla, 6,500 ft., 11 (USBS); Coyote Creek, 3 (USBS); *Santa Fe Co.*, 4 mi. NE Santa Fe, 1 (UI); 20 mi. W Santa Fe, 5 (UI); 10 mi. SE Santa Fe, 2 (UI); 18 mi. SW Santa Fe, 2 (UI); 19 mi. SW Santa Fe, 2 (UI); Glorieta, 1 (USBS); *Valencia Co.*, Grants, 17 (USBS); 3 mi. WSW Grants, Zuni Canyon, 3 (UM); 5 mi. WSW Grants, Zuni Canyon, 1 (UM); 1½ mi. S. Grants, 15 (UM); 17 mi. SW Grants, near Flagpole Crater, 17 (UM); 8 mi. SE Paxton, 8 (UM); 8 mi. SE Grants, 10 (UM); 9 mi. SSE Grants, 4 (UM); 1 mi. N Cebolleta, 5 (UM); 4 mi. N Cebolleta, 3 (UM); *Catron Co.*, Datil Mountains, 2 (USBS); *Socorro Co.*, San Andreas Mts., W slope Salinas Peak, 5,600 ft., 13 (USBS); *Taos Co.*, Arroyo Hondo, 7,600 ft., 2 (USBS); 2 mi. N Arroyoseco, 8,000 ft., 7 (USBS); *Colfax Co.*, Catskill, 3 (USBS); 7 mi. SW Catskill, 1 (USBS); 1½ mi. W Ranch Hdqts., Philmont Ranch, 6,700 ft., 2 (AM); Cimarroncito Canyon, 8 mi. W Cimarron, Philmont Ranch, 8,600 ft., 4 (AM); mouth Cimarroncito Canyon, 7 mi. W Cimarron, Philmont Ranch, 7,800 ft., 6 (AM); *Union Co.*, Clayton, 1 (USBS); Folsom, 4 (USBS); Emery Peak, 2 (USBS); Sierra Grande, 11 (USBS); *Mora Co.*, Hall's Peak, 2 (USBS); *San Miguel Co.*, 10 mi. S Mora, 1 (USBS); Pecos River, 7,400 ft., 3 (USBS); *Quay Co.*, Tucumcari, 1 (USBS); *Guadalupe Co.*, Santa Rosa, 3 (USBS); *Lincoln Co.*, Capitan Mountains, 25 (USBS); Corona, 1 (USBS); 40 mi. SE Corona, Gallo Canyon, 1 (USBS); Jacarilla Mountains, 19 (USBS). ARIZONA: *Apache Co.*, Springerville, 2 (USBS); 3 mi. S Springerville, 4 (USBS); Canyon del Muerto, 1 (USBS); *Cochise Co.*, 1¼ mi. E Fly's Peak, Greenhouse Canyon, Chiricahua Mts., 7,500 ft., 14 (UI); Sentinel Peak, Chiricahua Mts., 8,990 ft., 10 (AM); 1 mi. S Fly's Peak, 2 (UM); Rustler Park, 1 (UM). COAHUILA: Carmen Mts., 6,000 ft., 3 (USBS); 5 mi. W, 22 mi. S Ocampo, 10 (KU); Sierra del Pino, 5 mi. N, 9 mi. W Acebuches, 7,925 ft., 2 (KU); 26 mi. W Santa Teresa, 7,050 ft., 3 (KU); 2 mi. N, 18 mi. W Santa Teresa, 7 (KU).

Peromyscus difficilis griseus Benson

Peromyscus nasutus griseus Benson, 1932, Univ. Calif. Publ. Zool., 38: 338, April 14.

Type locality.—The Malpais, 3½ mi. W Carrizozo, 5,150 ft., Lincoln County, New Mexico.

Range.—Lava beds in Tularosa Basin, New Mexico.

Diagnosis.—A race of *Peromyscus difficilis* closely related to *P. d. nasutus*, but with darker color, principally as the result of a reduction of the yellows and ochraceous; underparts usually suffused with buffy.

Comparisons.—Differs from *P. d. nasutus* in darker color on dorsum and in more buffy on venter; buffy band in pectoral region.

Remarks.—The race of *P. d. griseus* is associated with the older lava beds

of central New Mexico. It is indistinguishable from *nasutus* except for darker coloration. Some specimens referred to *P. d. nasutus* from the lava beds in northwestern (Valencia County) New Mexico are as dark as specimens of *griseus* (*fide*, Hooper, 1941: 31).

Measurements.—One male, 6 females from 4 mi. W Carrizozo: *external*—198.6, 101.9, 22.7, 18.9; *cranial*—28.7, 21.4, 13.4, 4.5, 10.9, 4.5, 5.8, 7.4, 10.0, 4.3.

Specimens examined.—Total, 28. NEW MEXICO: *Lincoln Co.*, 3½ mi. W Carrizozo, 5,150 ft., 7 (MVZ); 4 mi. W Carrizozo, 8 (CM); French's Ranch, 12 mi. NW Carrizozo, 7 (3, MVZ; 4, CM); 6½ mi. W Oscuro, 4 (AM); *Socorro Co.*, North Cerro Prieto, 1 (MVZ); *Otero Co.*, 14 mi. W Three Rivers, 1 (MVZ).

Peromyscus difficilis comanche Blair

Peromyscus comanche Blair, 1943, Contrib. Lab. Vert. Zool., Univ. Mich., 24: 7, July.

Peromyscus nasutus comanche, Hoffmeister, 1951, Illinois Biol. Monogr., 21: 25, Nov. 12.

Type locality.—Tule Canyon, about 22 mi. E Tulia, Briscoe County, Texas.

Range.—Northwestern Texas, in Tule and Palo Duro canyons.

Diagnosis.—A race of *P. difficilis*, most closely related to *P. d. nasutus*, with small ears, short tail, small auditory bullae; ochraceous color of dorsum.

Comparisons.—From *P. d. nasutus*, *comanche* differs in more ochraceous or reddish coloration of dorsum, slightly smaller ears and auditory bullae, and shorter tail.

Remarks.—One of us (H) examined most of the paratypes of *comanche*. The one specimen examined from Cooper's Canyon proved referable to *P. boylii*. All specimens from Tule Canyon, together with those from south of Amarillo, seem referable to *comanche*.

Specimens examined.—Total, 15. TEXAS: *Briscoe Co.*, Tule Canyon, 22 mi. E Tulia, 12 (UM); *Randall Co.*, 21 mi. S [? SE] Amarillo, 3 (TU).

Peromyscus difficilis petricola Hoffmeister and de la Torre

Peromyscus difficilis petricola Hoffmeister and de la Torre, 1959, Proc. Biol. Soc. Wash., 72: 167, Nov. 4.

Type locality.—12 mi. E San Antonio de las Alazanas, 9,000 ft., Coahuila, México.

Range.—The Sierra Madre Oriental of southeastern Coahuila, northern San Luis Potosí, southwestern Tamaulipas, and probably southern Nuevo León.

Diagnosis.—A race of *Peromyscus difficilis* characterized by long body, relatively short tail, with head and body averaging about 95 per cent of tail length (in topotypes), relatively short hind foot (in topotypes), greatly inflated auditory bullae, broad braincase, broad interorbital region, long skull, particularly nasals, toothrow, and palatine slits, dorsum dark-colored and lacking the ochraceous of some subspecies.

Comparisons.—From *P. d. difficilis, petricola* differs as follows: pelage on dorsum has peppery appearance and slightly less ochraceous; less buffy on cheeks; underparts more blackish as a result of shorter white tips on the hairs; longer body, especially relative to tail; smaller hind foot (in topotypes of *petricola*); larger auditory bullae; broader braincase; slightly longer skull as reflected by longer nasals, palatine slits, diastema, upper toothrow, and post-palatal region.

From *P. d. nasutus, petricola* differs as follows: darker color, both with more blackish, less ochraceous, and a more pronounced peppery appearance; less buffy on cheeks; underparts darker; longer body; larger ear; larger auditory bullae; longer skull, especially as shown by longer nasals, diastema, palatine slits, post-palatal region, and upper toothrow; broader braincase.

Remarks.—*P. d. petricola* is a large, dark race with large auditory bullae. In specimens from Coahuila, the inflation of the bullae is greatest for the subspecies, and appears to be considerably greater than in nearby populations of *nasutus* and *difficilis*. However, the specimens from Miquihuana, Tamaulipas, show intergradation between *petricola* and *difficilis*.

Specimens from northern San Luis Potosí (Santa Ana) are referable to *petricola* primarily on the basis of large skull, greatly inflated auditory bullae, short body, short tail, and less buffy cheeks. These same specimens show intergradation with *P. d. difficilis* in that the underparts are not as blackish as in typical *petricola* and the pelage has a less peppery appearance and is lighter in color.

Measurements.—Three males, four females, from the type locality: *external*—224.3, 115.5, 23.4, 21.4; *cranial*—30.0, 22.6, 13.9, 4.6, 11.5, 4.4, 6.4, 7.7, 10.7, 4.8.

Specimens examined.—Total, 32. COAHUILA: 12 mi. E San Antonio de las Alazanas, 9,000 ft., 9 (KU). TAMAULIPAS: Miquihuana, 12 (USBS). SAN LUIS POTOSÍ: Santa Ana, 2 mi. E Catorce, 11 (LSU).

Peromyscus difficilis saxicola Hoffmeister and de la Torre

Peromyscus difficilis saxicola Hoffmeister and de la Torre, 1959, Proc. Biol. Soc. Wash., 72: 168, Nov. 4.

Type locality.—Cadereyta, 2,100 meters, Querétaro, México.

Range.—Querétaro and northern half of Hidalgo.

Diagnosis.—A race of *Peromyscus difficilis* characterized by brownish red or ochraceous color, with a reduced overlay of black permitting much of the ochraceous to show; ears more brownish than in other southern subspecies; dorsal tail stripe a mottled brownish; tail long; head and body averages 70.5 to 77 per cent of tail; hind foot not especially long; palate short.

Comparisons.—From *P. d. petricola, saxicola* differs as follows: more ochraceous color and a less peppery effect; underparts lighter; sides of face buffier; tail more brownish, less blackish; ears browner; body shorter and tail longer; auditory bullae less inflated; upper toothrow short; skull slightly smaller, in-

cluding nasals, palate, palatine slits; braincase slightly narrower; interorbital region narrower.

From *P. d. difficilis, saxicola* differs as follows: more ochraceous color of dorsum; sides of face buffier; ears slightly more brownish; tail longer; hind foot smaller; braincase slightly broader; post-palatal region longer; nasals and palate shorter.

From *P. d. amplus, saxicola* differs as follows: color on dorsum paler; ears lighter; dorsal tail stripe browner; pectoral spot less evident; tail longer; skull smaller in several features, including shorter upper toothrow, nasals, palate, and post-palatal region.

Remarks.—*P. d. saxicola* has a distinctive, dull, ochraceous color, without black on the dorsum.

Specimens from northern Hidalgo (Encarnación) are large for the subspecies and in this respect show intergradation with *P. d. petricola.* The larger size is not only in external features, but also in a larger skull, including a long upper toothrow. Although the specimens are intermediate in some morphological features, in color they are most like *saxicola,* being only slightly darker than topotypes.

Measurements.—Four males, five females from the type locality: *external*—232.5, 134.7, 23.7, 21.6; *cranial*—29.3, 22.4, 13.5, 4.5, 11.2, 4.2, 6.1, 7.5, 10.7, 4.5.

Specimens examined.—Total, 62. QUERÉTARO: Cadereyta, 2,000 m. and 2,100 m., 26 (UI). HIDALGO: Encarnación, 7 (USBS); Zimapán, 9 (USBS); 26 km. E Zimapán, 2 (UM); San Agustín (Metzquititlán), 7 (UI); 7 mi. S Puente de Tasquilla, 5,700 ft., 5 (MVZ); Ixmiquilpán, 6 (USBS).

Peromyscus difficilis amplus Osgood

Peromyscus amplus Osgood, 1904, Proc. Biol. Soc. Wash., 17: 62, March 21.
Peromyscus difficilis amplus, Osgood, 1909, N. Amer. Fauna, 28: 181, April 17.

Type locality.—Coixtlahuaca, Oaxaca, México.

Range.—Mountains of southern Hidalgo, northern México (state), Tlaxcala, Puebla, extreme west-central Vera Cruz, and northwestern Oaxaca.

Diagnosis.—A race of *P. difficilis* of large size, with large body and relatively short tail; large skull with long nasals, large toothrows, long post-palatal area, and large bullae; dark and reddish color with considerable ochraceous showing through the blackish overlay; dorsal tail stripe dark.

Comparisons.—Differs from *P. d. difficilis* externally by the dull reddish color with considerable black on dorsum and larger body size.

Remarks.—The individuals of the race *amplus* are large and lack the dark over-all color of the adjacent race *felipensis.* The races *saxicola, amplus* and *felipensis* have a dull appearance to the fur, in contrast with the more glossy fur of *P. d. difficilis.* All three races are more unicolor than *difficilis,* in which the dorsal black band is in sharp contrast with the yellow ochraceous color of the rest of the dorsum and sides. The ochraceous color is redder, darker and

duller in *amplus* than in *difficilis*. The race *amplus* has much more over-all blackish color than *saxicola* but much less than *felipensis*.

Specimens from the western part of the state of México at Atlacomulco, near the purported range of *felipensis*, are clearly referable to *amplus*.

Measurements.—Three males, five females, adults, from vicinity of Tlaxcala, Tlaxcala: *external*—234.5, 122.5, 24.9, 21.4; *cranial*—30.3, 23.2, 13.8, 4.7, 11.5, 4.5, 6.2, 7.6, 11.1, 4.9.

Specimens examined.—Total, 40. México: Atlacomulco, 2,600 m., 18 (UI); Cerro La Caldera, 11 mi. SE México, 2,350 m., 1 (UI). Tlaxcala: 13 km. NE Tlaxcala, 7,800 ft., 4 (UI); 6 mi. NE Tlaxcala, S side Atlihuetzia, 8 (UI); 8 km. SW Tlaxcala, 7,500 ft., 1 (UI). Puebla: Rio Otlati, 8,700 ft., 7 (UI); Lago Salado, 253 km. E México, 8,000 ft., 1 (UI).

Peromyscus difficilis felipensis Merriam

Peromyscus felipensis Merriam, 1898, Proc. Biol. Soc. Wash., 12: 122, April 30.
Peromyscus difficilis felipensis, Osgood, 1909, N. Amer. Fauna, 28: 182, April 17.

Type locality.—Cerro San Felipe, 10,300 ft., Oaxaca, México.

Range.—Mountains surrounding the valley of México in Distrito Federal and México (state) and interruptedly in Cerro San Felipe and Mixtepéc, Oaxaca.

Diagnosis.—A race of *P. difficilis* characterized by large body and tail; large hind foot, large skull (largest of all subspecies), long nasals, fairly long toothrows, and broad braincase; blackish color (darkest of all subspecies); dorsal tail stripe very dark brown; underparts blackish suffused with silver.

Comparisons.—Differs from *P. d. amplus* by much darker color, larger size of skull.

Remarks.—*P. d. felipensis* is the darkest of all subspecies and appears to inhabit the highest altitudes. As presently understood, the range of *felipensis* is interrupted. Comparison of specimens of *felipensis* from Oaxaca with specimens from México reveals that in color and in skull-size, proportions, and shape, they are quite similar.

The valley of the Rio Balsas and its associated lowlands separate the highlands of the state of México from those of Guerrero, immediately to the south. If the two groups of populations (México and Oaxaca) are truly of the same subspecies, geographical continuity must have been achieved at one time by way of the narrow corridor of highlands connecting Puebla and Oaxaca. Yet, it appears that this mouse has not been taken in Puebla. We thus see three possibilities which should be studied. These are: (1) that the southern populations are actually of a different stock similarly reacting to similar environmental conditions; (2) that the southern and northern populations are continuous along the highest altitudes of the México-Puebla-Oaxaca highlands; and (3) that the southern and northern populations are both derived from the same stock (possibly *amplus*-like) and that they thus represent similar adaptations

by different segments of a single stock evolving in response to similar but new environmental conditions.

Measurements.—Five males, one female, adults, from Contreras, Distrito Federal: *external*—243.8, 134.8, 26.8, 21.5; *cranial*—31.1, 23.6, 14.5, 4.5, 12.0, 4.6, 6.3, 8.1, 11.1, 4.8.

Seven, four males, three females, from Cerro San Felipe, Oaxaca: *external*—240.0, 125.3, 26.8, – –; *cranial*—31.3, 23.7, 14.1, 4.6, 12.1, 4.7, 6.8, 8.3, 11.1, 4.96.

Specimens examined.—Total, 45. DISTRITO FEDERAL: Contreras, 2,800 m., 6 (UI); Ajusco, 3 (USBS). MÉXICO: Salazár, 4 (USBS); Amecameca, 8 (USBS); Toluca Valley, 5 (USBS). OAXACA: Cerro San Felipe, 19 (USBS).

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Museum of Natural History, Univ. of Illinois, Urbana. (Current address of junior author: Dept. of Dairy Science, Univ. of Illinois, Urbana.) *Received 5 October 1959.*

DISTRIBUTION AND ECOLOGY OF THE HISPID AND LEAST COTTON RATS IN NEW MEXICO

BY JOHN S. MOHLHENRICH

ABSTRACT: Parts of three years were spent locating populations of cotton rats, *Sigmodon hispidus* and *S. minimus*, in New Mexico, with the objective of determining distributional limits and ecological preferences of the animals. One hundred twenty-one populations were located and 730 specimens were taken. Neither species seems to occur regularly in areas which have a mean annual temperature of less than 55°F or a growing season of less than 180 days. Both species have similar ecological preferences but, where the two kinds occur in the same area, *S. minimus* extends to somewhat greater altitudes than does *S. hispidus*. There is some evidence that both species have extended their ranges northward in recent years.

Of the three species of cotton rats known to occur in New Mexico, the least cotton rat, *Sigmodon minimus*, and the hispid cotton rat, *S. hispidus*, are widely distributed in various parts of the state. Since little information seems to be on record concerning the distribution or ecology of these animals in this area, a study was made to elucidate these subjects.

I am indebted to James S. Findley for his encouragement and guidance throughout the study. William C. Martin aided in the identification of plants.

George E. Barclay and F. Sheldon Dart, of the U.S. Fish and Wildlife Service, were most cooperative in allowing me to study cotton rats at Bosque del Apache Wildlife Refuge.

MATERIALS AND METHODS

Field work was carried out from February to May 1957, from October 1957 to May 1958, and from September 1958 to March 1959. The work consisted of a search for and a study of *Sigmodon* populations in New Mexico.

Specimens were obtained by placing snap traps baited with oatmeal in the runways. In some cases these traps were left overnight and picked up the following morning. In other instances the trapline was set for periods varying from 15 minutes to several hours. The number of cotton rats obtained by the latter method did not seem greatly reduced. For instance, 15 traps set for 20 minutes at Hondo, Lincoln County, yielded eight *S. hispidus*. All cotton rats collected are preserved in the University of New Mexico Collection of Vertebrates.

Samples of the vegetation were taken from the habitat of each cotton rat population. Kearney and Peebles (1951) is the source of most of the scientific and common plant names. Plant specimens collected are deposited in the University of New Mexico Herbarium. Climatological data for many stations were obtained from the records of the U.S. Weather Bureau. Precise location and elevation of collecting stations were obtained from the 1955 provisional edition of the New Mexico base map of the U.S. Geological Survey.

Of the 121 cotton rat populations found, 34 contained *S. minimus* only, 74 *S. hispidus* only, and 13 contained representatives of both species. This information is summarized in the Locality List and in Fig. 1. A total of 730 cotton rats was taken.

FINDINGS

On the basis of the distributional pattern of *Sigmodon* in New Mexico, the state was divided into two major geographic regions: eastern and western. Eastern New Mexico, where only *S. hispidus* was found, includes all of the state east of the Rio Grande Valley. Western New Mexico, in which both species occur, includes the Rio Grande Valley and all of the state west of the Rio Grande. Southwestern New Mexico, a subdivision of the latter region, includes all of the state south of the Sierra County-Socorro County line and west of the Rio Grande Valley. This is the area in which *S. minimus* populations, *S. hispidus* populations, and populations containing both species occur, and in which both *S. hispidus* and *S. minimus* might be expected.

Eighty-seven kinds of plants were obtained at or near the *Sigmodon* record-stations found during this study. Thirty-seven kinds of plants were found both with populations containing *S. minimus* only and with those containing *S. hispidus* only. Twenty-nine kinds were found with *S. hispidus* populations only, and 18 kinds with *S. minimus* populations only. Twenty-one kinds of plants

were associated with populations containing members of both species. In general, the plant associates of *S. minimus* and of *S. hispidus* in New Mexico are similar. Differences are noted when only the cotton rat populations found in western New Mexico are compared. As an example, cottonwood (*Populus wislizeni*) is associated with 27 per cent of the populations containing *S. minimus* only and with 27 per cent of those containing *S. hispidus* only. If *S. hispidus* populations of eastern New Mexico are excluded, cottonwood occurs

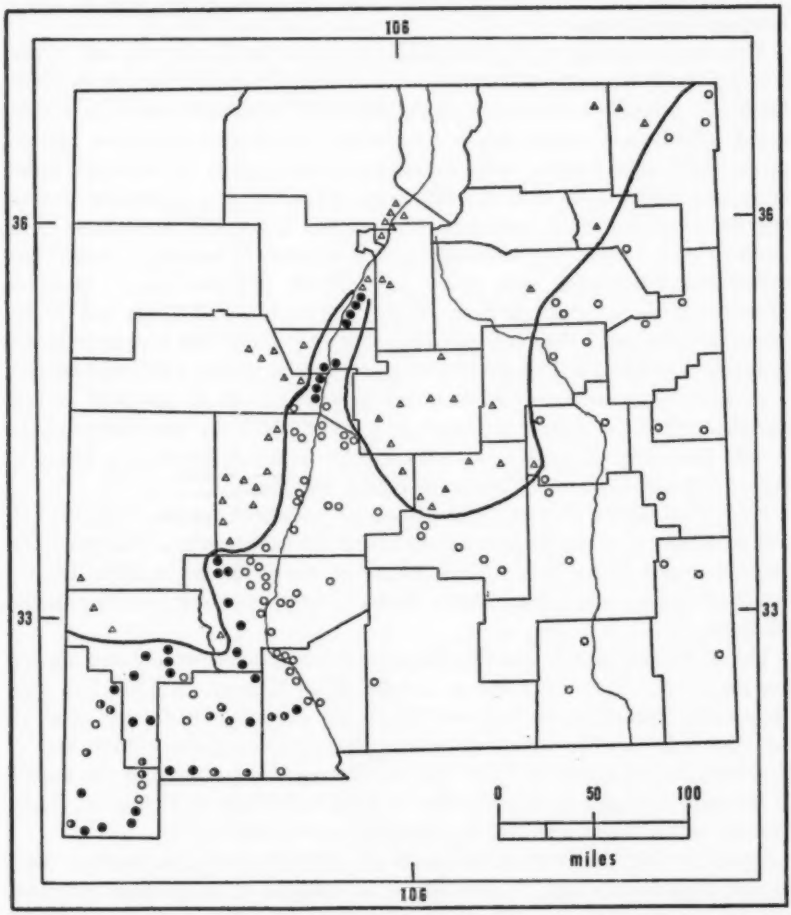

FIG. 1.—Map showing locations of *Sigmodon* populations found in New Mexico during the present study. Open circles indicate populations of *S. hispidus* only; solid circles, *S. minimus* only; half open circles, the two species occurring together in one population. Triangles indicate areas in which no *Sigmodon* was found; dark line the northern limits of *Sigmodon* in the state.

at the localities of 53 per cent of the S. *hispidus* populations, and thus is more characteristic of S. *hispidus* stations than of S. *minimus* stations in western New Mexico.

Few of the plants found associated only with S. *minimus* or S. *hispidus* were present at more than one or two stations. Only two of these plants, soapweed (*Yucca glauca*) and saltbrush (*Atriplex canescens*), were associated with 10 per cent or more of the S. *hispidus* populations. All of the plants found only at S. *minimus* stations were associated with less than 10 per cent of the S. *minimus* populations.

Sigmodon minimus only is associated with pinyon and evergreen oak (*Quercus* spp.) and is associated three times as often with juniper as is S. *hispidus*. *Sigmodon hispidus* is more commonly associated with such plants as cottonwood, joint-fir and cattail than is S. *minimus*. In southwestern New Mexico, as the vegetation became more sparse and more typical of disturbed areas, increasing percentages of S. *hispidus* were taken. As the vegetation became less disturbed and as it provided better cover, increasing percentages of S. *minimus* were taken. In southwestern New Mexico, S. *hispidus* is more commonly associated with such plants as saltbush (*Atriplex* spp.), mesquite (*Prosopis juliflora*), creosote-bush (*Larrea tridentata*), and cholla and prickly pear (*Opuntia* spp.) than is S. *minimus*. *Sigmodon minimus* is more common in swales containing a thick growth of grass, such as galleta (*Hilaria Jamesii*).

These slightly different vegetational preferences of S. *minimus* and S. *hispidus* reflect the slightly different altitudes at which the two forms may be found. In western New Mexico, with one exception, S. *minimus* is found at higher altitudes than is S. *hispidus* at similar latitudes.

Vegetation similar to that found associated with both species of cotton rats was found north of the northernmost stations for each species. The grass and marsh habitats in the Rio Grande Valley in the vicinities of Pena Blanca, Sandoval County, and Espanola, Rio Arriba County, seemed especially suitable for *Sigmodon*.

The elevations of the localities from which *Sigmodon* were taken during this study vary from 3,400 feet at Artesia, Eddy County, to 7,000 feet near Monticello, Sierra County (see Locality List). The altitudinal range of all of the known S. *hispidus* record-stations in New Mexico is from 3,100 feet at Carlsbad, Eddy County, to 7,000 feet near Monticello, and that of the known S. *minimus* localities in New Mexico is from 4,000 feet at Columbus, Luna County, to 6,300 feet near White Signal, Grant County.

Sigmodon hispidus was often taken at higher altitudes in eastern New Mexico than were either S. *minimus* or S. *hispidus* at comparable latitudes west of the Rio Grande. When record-stations of both species are present at similar latitudes in western New Mexico, the record-station at the highest altitude is usually that of S. *minimus* (Fig. 2). In this region one S. *hispidus* station, near Monticello, Sierra County, is at a higher altitude than the highest

S. minimus locality. Local exposure conditions at this station have caused lower zone plants to ascend to an unusual altitude.

In southwestern New Mexico, collections from increasingly higher stations contained increasing proportions of *S. minimus* until in the foothills pure *S. minimus* populations were usually found. *Sigmodon hispidus* became increasingly abundant at lower altitudes. The effect of elevation upon the dis-

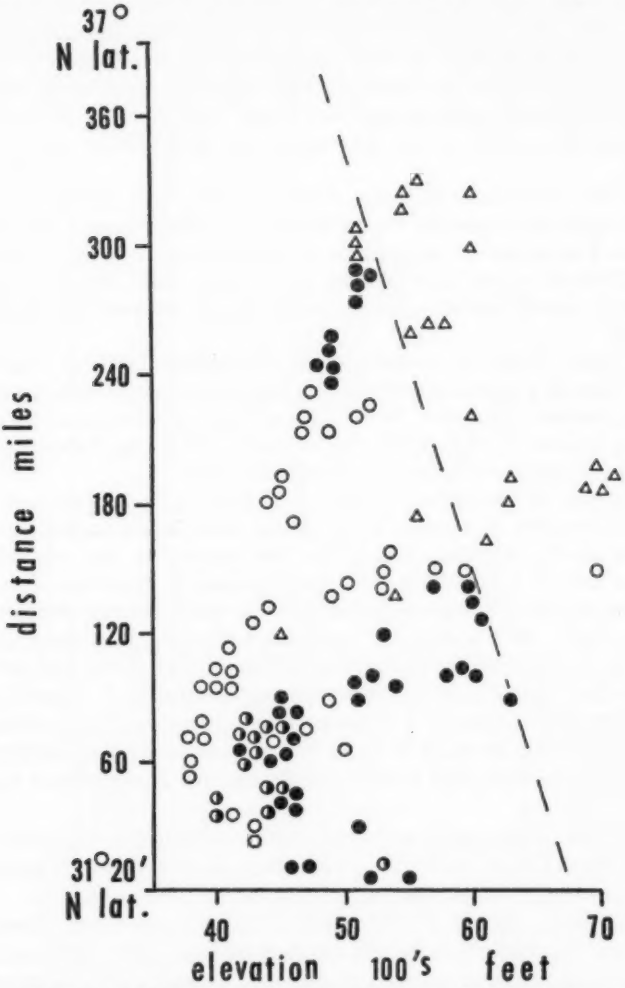

FIG. 2.—Elevation and latitude as related to distribution of *Sigmodon* in western New Mexico. Broken line connects points of comparable climate and, in general, corresponds to the upper altitudinal limit of *Sigmodon* at any given latitude. Symbols as in Fig. 1.

tribution of the two species is demonstrated by the yields from record-stations along a transect between the southern Playas Valley, Hidalgo County, and Silver City, Grant County. The two populations at the lowest altitude, 4,300 feet, contained *S. hispidus*; two at 4,500 feet were mixed populations and a third contained *S. minimus* only. The remaining four populations at elevations between 4,600 and 6,300 feet contained only *S. minimus*.

Climatic data were obtained for six *S. minimus* stations, 26 *S. hispidus* stations, five record-stations from which members of both species were taken, and for 16 of the localities at which no cotton rats were found.

Rainfall seems not to be correlated with *Sigmodon* distribution and neither species of cotton rat seems to need free water. Both occur in marshes or near ponds, but the majority of rats was taken from arid hillsides, piedmonts and plains.

With two exceptions—Winston, Sierra County, and Mosquero, Harding County—all of the *Sigmodon* record-stations for which climatic data are available have a mean annual temperature of more than 55.0° (Fig. 3), while only two localities at which no *Sigmodon* were found—Cliff, Grant County, and Glenwood, Catron County—have a mean annual temperature in excess of this level.

Only three cotton rat record-stations—Bernalillo, Sandoval County, Los Lunas, Valencia County, and Mosquero, Harding County—have a mean January temperature of less than 34.0°, while all but two of the localities at which no cotton rats were found—Cliff, Grant County, and Ancho, Lincoln County—have a mean January temperature of less than 34.0°.

Comparison of the mean January and mean July temperatures among cotton rat localities in western New Mexico shows some temperature difference between the record-stations of the two species. In this area, all of the record-stations of *S. hispidus* have a mean January temperature of more than 37°. Four of the *S. minimus* stations have a mean January temperature of less than 36.0°. In this area, the total range in mean January temperatures among the *S. hispidus* record-stations is from 37.4 to 43.8°, and that for *S. minimus*, 31.6 to 43.8°. In the same geographic area, no *S. hispidus* record-stations, but five stations for *S. minimus*, have a mean July temperature below 78.0°. For this area the range in mean July temperatures among the *S. hispidus* record-stations is from 78.0 to 82.5°, while that for *S. minimus* is from 71.9 to 82.5°.

All but three of the cotton rat record-stations—Bernalillo, Sandoval County, Winston, Sierra County, and White Sands National Monument, Otero County—have an average growing season of 180 days or more (Fig. 3).

The maximum altitude at which cotton rats may be found decreases at progressively more northern stations. So does the maximum altitude of stations with a growing season of 180 days or more and a mean annual temperature of 55.0° or more. In eastern New Mexico, *S. hispidus* occurs as far north as the Cimarron Valley, Union County, which has an altitude low enough to provide

suitable temperature and growing season for the animals. In the Rio Grande Valley, the maximal altitude of the presumed correct temperature and growing season decreases northward until it coincides with the lowest altitude available. North of this point no area is climatically suitable for *Sigmodon* and none occurs.

DISCUSSION

It seems clear that temperature and growing season are important factors controlling *Sigmodon* distribution in New Mexico. This hypothesis was tested in eastern New Mexico. On the basis of the climatic and altitudinal data, it was predicted that cotton rats should be expected at Carrizozo, Lincoln

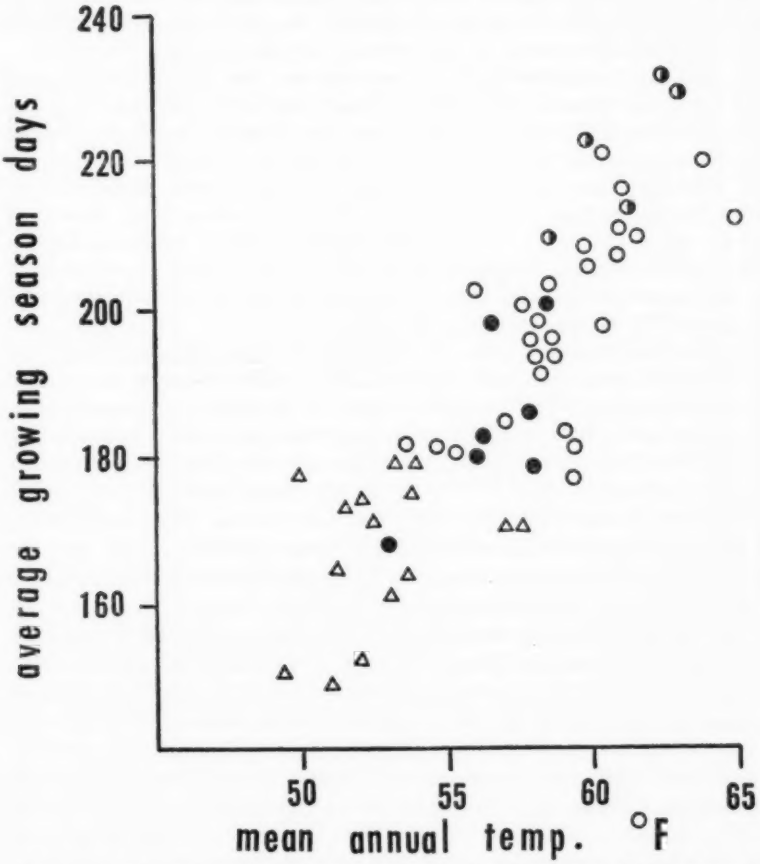

FIG. 3.—Temperature and growing season as related to distribution of *Sigmodon* in New Mexico. Symbols as in Fig. 1.

County, in the Cimarron Valley, Union County, and throughout the plains east of the Pecos River, but should not occur at Corona, Lincoln County, at Roy, Harding County, or at Des Moines, Union County. Results of the field work in eastern New Mexico show that the distribution of *S. hispidus* corresponds to the predicted pattern. This similarity demonstrates the feasibility of predicting the presence or absence of *Sigmodon* at any given locality in New Mexico if the mean temperatures, average growing season, and altitude of the locality are known.

The presence of one species of cotton rat may limit the distribution of the other species. Since *S. hispidus* occurs at higher elevations in eastern New Mexico than in the western part of the state, it is probable that the upper altitudinal limit of *S. hispidus* in western New Mexico is determined by the presence of *S. minimus*. Similarly, it is possible that the lower altitudinal limit of *S. minimus* is determined by the presence of *S. hispidus*.

Sigmodon occurs farther north in New Mexico than previously published records indicate. A northward extension of the range of the genus is suggested. In the Rio Grande Valley the northernmost record of *S. hispidus* is 40 miles north of the previously known northern record-station at Socorro (Bailey, 1931: 167), and *S. minimus* is now known to occur 35 miles north of the previous northern record-station at Isleta (Ivey, 1957). In eastern New Mexico, *S. hispidus* was taken as far north as the Cimarron Valley in Union County, 3 miles west of Kenton, Oklahoma. The latter record provides a range extension northeastward from the Pintada Arroyo, Guadalupe County (Anderson and Berg, 1959) of approximately 174 miles.

Sigmodon minimus was taken near Bernardo in 1940 (Gardner, 1948). In 1958, only *S. hispidus* was taken at this locality and 17 miles to the north at Belen. In October 1948, Ivey (1957) found *S. minimus* at Isleta, 35 miles north of Bernardo, in Bernalillo County. Ivey had searched for cotton rats in Bernalillo County before October 1948, without success (personal communication to J. S. Findley). Prior to 1948 William J. Koster had repeatedly looked for *Sigmodon* in the vicinity of Isleta, with no success. It is doubtful that *S. minimus* was present in Bernalillo County prior to 1948.

Evidence for northward movement of *S. hispidus* in eastern New Mexico is not so clear. The *S. hispidus* locality in the Cimarron Valley is 174 miles northeast of Pintada Arroyo, the northernmost published record-station in eastern New Mexico (Anderson and Berg, 1959). In 1946, *S. hispidus* was first taken in southeastern Colorado at a locality 11 miles north of Springfield (Goldman and Gardner, 1947). The species probably has a continuous distribution between northeastern New Mexico and southeastern Colorado, and probably between both stations and more eastern localities. It is difficult at this point to determine if these records represent range extensions from south or east of if the animals have been present for some time and are now revealed by more intensive collecting.

Sigmodon minimus was not found in the Rio Grande Valley south of Belen

during the present study, but in 1909 Goldman (Bailey, 1913) obtained examples of this species at Truth or Consequences, Sierra County (Gardner, 1947). Only *S. hispidus* was taken at Truth or Consequences during the present study. A similar situation was discovered by Adrey Borell in the 1930's (personal communication to J. S. Findley, 1957). In 1909, Goldman (H. Setzer, *in litt.*, 11 Dec. 1958) found *S. hispidus* in the Rio Grande Valley at Socorro, 65 miles northeast of Truth or Consequences.

Goldman's itinerary (F. M. Bailey, 1928: 34) shows that the day after he took *S. minimus* at Truth or Consequences (then Hot Springs) he traveled to Hillsboro, near which *S. minimus* was taken during the present study. This suggests that a confusion in localities might have occurred, but the habitat in which Goldman (Bailey, 1931: 170) found *S. minimus* is more typical of the Rio Grande Valley than of the foothills among which Hillsboro is located.

Probably *S. minimus* has not moved northward to Algodones, Sandoval County, from Truth or Consequences, Sierra County, since 1909, as at that date *S. hispidus* was north of *S. minimus* in the Rio Grande Valley. It seems more likely that *S. minimus* sometimes "spills over" from the western mesas into the valley. This could account for its presence at Truth or Consequences in 1909. Likely *S. minimus* was established in the valley somewhere north of Socorro as early as 1909, and has since moved northward while withdrawing from more southern parts of the valley.

The one published record of *Sigmodon minimus* east of the Rio Grande (Dice, 1930: 26) has been shown to be in error (Dice and Blossom, 1937: 37). The absence of *S. minimus* in eastern New Mexico cannot be attributed to lack of suitable habitat, as habitat similar to that occupied by the species in the western part of the state is present east of the Rio Grande Valley. Instead, this absence may be related to the past distributional history of *Sigmodon* in the state. At least two separate sequences of events, both related to climatic change causing northward movements of both species, could have resulted in the present distribution.

The presence of *S. minimus* in the Rio Grande Valley north of *S. hispidus* suggests that *S. minimus* became established in the valley before the latter species. As climatic warming and drying took place, *S. minimus* would have been expected to invade the foothills on either side of the Rio Grande as well as to move northward in the valley. The absence of *S. minimus* from the foothills and mountains east of the Rio Grande seems to negate this theory. A second hypothesis assumes that *S. minimus* was never established in the southern Rio Grande Valley in New Mexico, but that it became established in southwestern New Mexico while *S. hispidus* became established in southern New Mexico from the Rio Grande Valley eastward. Change in climate resulted in both species moving northward, *S. hispidus* through the Rio Grande Valley and the country to the east, and *S. minimus* along the foothills west of the river. As *S. minimus* progressed northward, the latitudinal effects upon climate forced the species to successively lower altitudes, ultimately into the Rio

Grande Valley. This hypothesis explains why *S. minimus* does not occur east of the Rio Grande Valley.

Sigmodon minimus is seemingly not so well adapted to low altitudes as is *S. hispidus* and does not easily become established in low areas occupied by *S. hispidus*. However, the least cotton rat, if in the area, should have been able to cross the lower Rio Grande Valley in New Mexico in the past when climatic conditions at low elevations differed from those existent today. It seems likely to me that *S. minimus* has never been established in the southern Rio Grande Valley in New Mexico.

CONCLUSIONS

1. Within the entire range of *Sigmodon* in New Mexico, *S. minimus* and *S. hispidus* occupy similar habitats. Both species may be associated with similar vegetative types and both species range from low river valleys to mountains.
2. *Sigmodon hispidus* appears to tolerate a wider range of temperatures and altitudes than does *S. minimus*.
3. In areas where both species occur, each tends to be found in situations to which it is seemingly better adapted. In such areas, *S. minimus* is more common at higher elevations with lower temperatures and in situations containing more vegetative cover. *Sigmodon hispidus* is more abundant at lower elevations with higher temperatures and in areas of more sparse vegetative cover.
4. The two species are not mutually exclusive, but mixed populations are not common in New Mexico.
5. Neither *S. hispidus* nor *S. minimus* seems to need a constant source of free water.
6. Neither lack of suitable vegetation nor amount of rainfall directly affects the distribution of cotton rats in New Mexico.
7. Temperature directly affects the distribution of *Sigmodon*. In New Mexico, cotton rats generally occur only in areas which have a mean annual temperature of 55.0°F or above, a mean January temperature above 34.0°F, and a mean July temperature of 75.0°F or above.
8. Cotton rats usually occur in areas having an average growing season of at least 180 days.
9. The maximum altitude at which cotton rats may be found decreases at progressively more northern stations because of the latitudinal effects upon climate.
10. The presence of one species of cotton rat may limit the distribution of the other species.
11. *Sigmodon* occurs farther north in New Mexico than previously published records indicate. In the Rio Grande Valley, the northern range of *S. minimus* has been extended 35 miles, that of *S. hispidus*, 40 miles. In eastern New Mexico, the range of *S. hispidus* has been extended approximately 174 miles northeastward from the previous northern record-station in that portion of the state.

12. The present pattern of *Sigmodon* distribution in New Mexico suggests that *S. hispidus* entered the state from the southeast, and that *S. minimus* entered the state from the southwest.

13. The absence of *S. minimus* in eastern New Mexico suggests that the species has never been established in the southern Rio Grande Valley in the state during the time that *Sigmodon* has been present in New Mexico.

LOCALITY LIST

Within each county the localities are listed in a north-south sequence. If more than one locality occurs at the same latitude, the sequence of localities at that latitude is from west to east. *Union Co.*: 3 mi. W Kenton (Oklahoma), 4500′; Mt. Dora, 5700′; 5 mi. S Moses, 4800′. *Sandoval Co.*: .5 mi. N and .5 mi. E Algodones, 5200′; Algodones, 5100′; Bernalillo, 5100′; 5 mi. S and 2 mi. W Bernalillo, 5100′. *Harding Co.*: Mosquero, 5500′. *Valencia Co.*: 5 mi. N and 1 mi. E Los Lunas, 4900′; 1 mi. N Los Lunas, 4900′; .5 mi. W and 1 mi. N Belen, 4700′; 2 mi. E and 1 mi. S Belen, 4700′; Pato Arroyo, 13 mi. W Bosque, 5200′. *Bernalillo Co.*: Isleta, 4900′; 2 mi. S and 1.5 mi. W Isleta, 4900′. *San Miguel Co.*: Variadero, 4500′; Conchas, 4200′; 4 mi. S and 2 mi. E Variadero, 4500′. *Quay Co.*: 1 mi. N and 1 mi. W Logan, 3900′; 4 mi. N and 1 mi. W Tucumcari, 4000′. *Socorro Co.*: Abeytas, 4700′; 1 mi. N and 6 mi. W Bernardo, 5100′; 4 mi. W Bernardo, 4900′; 3.5 mi. E Bernardo, 4700′; 6.5 mi. W Scholle, 5800′; Scholle, 5800′; 4 mi. W and 2 mi. S Scholle, 6000′; 1 mi. E Socorro, 4500′; 1 mi. E and 5 mi. N San Antonio, 4500′; 1 mi. E and 2 mi. N San Antonio, 4500′; Carthage, 5100′; 4 mi. E Carthage, 4900′; 5 mi. E and 4 mi. S Bingham, 6400′; Bosque del Apache National Wildlife Refuge, 4500′; 13 mi. E and 8 mi. N Monticello, 5400′. *Guadalupe Co.*: Newkirk, 4600′; Santa Rosa, 4600′. *Curry Co.*: 3 mi. W Melrose, 4400′; 5 mi. W Clovis, 4100′. *Grant Co.*: Bayard, 6000′; 2 mi. W and 4 mi. S Silver City, 5800′; 3.5 mi. S Hurley, 5400′; 2.5 mi. W White Signal, 6300′; 3 mi. E and 7 mi. S Hurley, 5100′; 1 mi. W and 2 mi. S Faywood, 4900′; Separ, 4500′; Wilna, 4500′; 1 mi. W Hachita, 4500′. *Sierra Co.*: 6 mi. N and 1 mi. W Winston, 5700′; 3 mi. E and 3 mi. N Monticello, 7000′; 6 mi. E and 1 mi. N Monticello, 6000′; Monticello, 5300′; 5 mi. E Winston, 6000′; 1 mi. S and 1 mi. W Winston, 6000′; 9.5 mi. E and 3.5 mi. S Monticello, 5000′; 9.5 mi. E and 6 mi. S Monticello, 4900′; 6 mi. E and 7 mi. S Monticello, 5300′; 16 mi. E and 4 mi. N Engle, 6500′; Engle, 4700′; Ladder Ranch, R. 7 W, T. 14 S, Sec. 4, 6100′; 5 mi. W and 3 mi. S Engle, 4900′; 4 mi. W and 3 mi. S Engle, 4800′; Truth or Consequences, 4400′; Las Palomas, 4300′; 4 mi. E and 2.5 mi. N Hillsboro, 5300′; 3 mi. N and 1 mi. E Arrey, 4100′; 2 mi. N and 1.5 mi. E Lake Valley, 5200′; 8 mi. N and 4.5 mi. W Nutt, 5100′. *Lincoln Co.*: 4 mi. N and 1 mi. E Carrizozo, 5500′; Carrizozo, 5500′; Capitan, 6300′; Lincoln, 5800′; Hondo, 5200′. *De Baca Co.*: 4 mi. E Cardenas, 5200′; 1 mi. S and 1 mi. E Fort Sumner, 4000′; 3 mi. N and 3 mi. W Mesa, 4700′. *Roosevelt Co.*: 1 mi. S and 1 mi. W Elida, 4300′. *Hidalgo Co.*: 7 mi. N and 4.5 mi. E Lordsburg, 4500′; 2 mi. E Lordsburg, 4200′; 4 mi. E and 2 mi. S Lordsburg, 4200′; 8.5 mi. S and 1.5 mi. W Lordsburg, 5000′; Animas, 4400′; 5 mi. S and 2 mi. W Hachita, 4500′; 15 mi. S and 8 mi. W Hachita, 4300′; 20 mi. S and 3 mi. W Animas, 5100′; 22 mi. S and 9 mi. W Hachita, 4300′; 9.5 mi. N and 2 mi. W Antelope Wells, 4600′; Cloverdale, 5300′; 5.5 mi. N and 3 mi. W Antelope Wells, 4700′; 12 mi. W Antelope Wells, 5500′; Lang Ranch, T.34 S, R.19 W, Sec. 19, 5200′. *Luna Co.*: 7.5 mi. E and 2 mi. N Nutt, 4500′; 4 mi. E and 2 mi. S Spalding, 4700′; 4 mi. S and 3 mi. W Florida, 4500′; 1 mi. W Deming, 4300′; 11 mi. W and 2 mi. S Deming, 4500′; 6.5 mi. W Akela, 4200′; 1 mi. S Akela, 4200′; 11 mi. E and 6 mi. S Hachita, 4500′; Hermanas, 4500′; 1 mi. E Columbus, 4000′; 13 mi. E and 2 mi. S Columbus, 4000′. *Dona Ana Co.*: 2 mi. W and 2 mi. N Salem, 4100′; 2 mi. W and 1 mi. N Salem, 4100′; Salem, 4100′; 4 mi. E and 1 mi. S Hatch, 3900′; 6 mi. E and 2 mi. S Hatch, 3900′; 3 mi. W and 3 mi. N Las Cruces, 3900′; 3 mi. W and 2 mi. N Las Cruces, 3900′; 16 mi. W and 1 mi. S Las Cruces, 4600′; 12 mi. E Akela, 4300′; 17.5 mi. E Akela, 4300′; Mt. Riley, 4100′. *Otero Co.*:

10 mi. S and 8 mi. W Headquarters, White Sands National Monument, 3900′. *Chaves Co.*: Mesa, 4600′; 3 mi. N Roswell, 3600′. *Eddy Co.*: 1 mi. S Artesia, 3400′; 3.5 mi. N and 13 mi. W Carlsbad, 3500′. *Lea Co.*: Caprock, 4100′; Tatum, 4000′; 2 mi. W Hobbs.

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Dept. of Biology, Univ. of New Mexico, Albuquerque. (Present address: Hawaii National Park, Maui.) *Received 10 August 1959.*

HOME RANGES, TERRITORIALITY, AND MOVEMENT OF THE MEADOW VOLE

BY LOWELL L. GETZ

ABSTRACT: Two populations of the meadow vole, *Microtus pennsylvanicus*, one inhabiting an abandoned field, the other a grass-sedge marsh, were live-trapped at monthly intervals from September 1957 through September 1958. The mean monthly home range size of the males was larger than that of the females in both areas. The home ranges of the females in the marsh were larger than those in the old field; there was no difference between the home range sizes of the males in the two areas. The home range size in the marsh varied inversely with population density. Environmental conditions in the old field, particularly low winter temperatures, exerted more influence upon home range size than did population density. The data indicate that *M. pennsylvanicus* displays territorial behavior. The degree of such behavior does not appear to be influenced by population density or environmental conditions. About 20 per cent of the population shifted their home ranges each month. A greater percentage of males moved than did females. The young voles displayed only a slightly greater tendency to move than did the adults.

Estimates of population densities of small mammals are most commonly derived from trapping data. The results of such trapping, whether live-traps

or snap-traps are utilized, depend not only on the actual abundance of the mammals, but also upon the methods employed and the behavior of the species. Sealander and James (1958), Goodnight and Koestner (1942), Hayne (1950), and Calhoun and Casby (1958) have presented data to show the influence of different types of traps as well as the positioning of the traps upon the derived population densities. Calhoun and Casby further indicated that differences in such factors as home range size, display of territoriality, or movement within populations may have a bearing upon densities derived from trapping data. Such behavioral information is relatively rare for even the more common species of small mammals.

The information herein was obtained as part of a 13-month study of the ecology of the meadow vole, *Microtus pennsylvanicus*, in southern Michigan. Two populations, one living in a grass-sedge marsh, the other in an abandoned field, were live-trapped at monthly intervals. A non-moving grid similar to that used by Blair (1940) was utilized. Such a method of trapping, although shown to give an inaccurate indication of the precise range of activity of a small mammal (Hayne, 1949; Calhoun and Casby, 1958), was used in view of other types of information desired. Since the data from both populations were treated similarly, I believe that valid comparative values have been obtained. My main purpose is to compare phenomena concerning home range sizes, display of territoriality, and movement within two meadow vole populations living in different habitats, rather than to attempt to give absolute values for these items.

I wish to thank W. H. Burt for assistance during the course of the study as well as in preparation of the manuscript. Appreciation is expressed also to L. S. Swanbeck and Argus Cameras, Division of Sylvania Electric, for permission to use a private drive to gain access to the study area in the marsh. The field work was done under the auspices of a Horace H. Rackham predoctoral fellowship at the University of Michigan.

DESCRIPTION OF THE STUDY AREA

Two areas, a 2.5-hectare abandoned field ("old field") and a grass-sedge marsh, were selected. Both are in the Mud Lake Research Area of the University of Michigan in Washtenaw County, Michigan. Vegetation in the old field consists primarily of *Poa compressa*, *Potentilla intermedia*, and *Daucus carota*. The soil here is a sandy loam (Miami loam), and relatively dry most of the year. The surface is rolling and well drained. Other small mammals present included *Cryptotis parva*, *Blarina brevicauda*, *Scalopus aquaticus*, and *Peromyscus leucopus*.

The marsh lies in a low, poorly drained area. The study area included 3.6 hectares. The surface is inundated, at least in part, from October through May. Even when not inundated the substrate is practically saturated. The soil is composed primarily of organic material. The vegetation consists mainly of various species of grasses and sedges and a fern, *Dryopteris thelypteris*. The amount

of grass-like vegetation is much greater in the marsh than in the old field (325 and 65 gr/m², respectively). Compared with the old field, the marsh is the more favorable vole habitat. For more complete descriptions of both habitats, see Getz (in press). Other small mammals present included *Sorex cinereus, Blarina brevicauda, Peromyscus leucopus, Synaptomys cooperi,* and *Zapus hudsonius.*

METHODS

Both areas were live-trapped with multiple-catch traps as described by Burt (1940). The non-moving grid had a 12-meter interval. Each station was trapped for five days and nights a month, September 1957 through September 1958. The traps were checked just after sunrise and again before dark. All individuals were marked by toe-clipping. For more complete details of the methods employed, see Getz (1960).

HOME RANGES

The home range concept in small mammals has received considerable attention in the past several years (for a more complete discussion, see Brown, 1956). The earlier workers obtained their data from live-traps placed in a non-moving grid pattern (Burt, 1940; Blair, 1940; Stickel, 1954). With such information, various methods were used to calculate the size of the apparent home ranges of the animals. Although there was considerable variation in the results, depending upon the method used, these studies succeeded in prescribing approximate sizes of the apparent home ranges of many species of small mammals. Godfrey (1954), utilizing both trapping and tracing of individuals marked with radioactive material, found the traps to yield reasonable estimates of the home ranges of *Microtus agrestis.* Recently such methods of trapping and calculation of home range sizes have been criticized by Hayne (1949) and Calhoun and Casby (1958). These authors have further devised methods whereby a more accurate impression of the home range or range of activity is obtained, one of which involves the use of a moving grid (Brown, 1954; Blair, 1951). Blair was able to track many of the mice (*Peromyscus polionotus leucocephalus*) on his study plot. These track records indicated the trap-revealed home ranges to be fairly reliable.

From the results of the above studies it is obvious that, in most species of small mammals, the movements of an individual are confined to a more or less restricted area, a home range. All individuals of a given species do not have the same size home range, however. It is of interest to find the factors responsible for such variations, especially the influences of population densities, environmental factors, and reproduction.

Home range sizes were determined for each trapping period (exclusive boundary method, Stickel, 1954). Those individuals captured less than three times in a given period and those that obviously had not established a home range were excluded from the compilations. Individuals caught in the border traps were not included unless the adjacent area was unfavorable vole habitat.

TABLE 1.—*Percentages of Microtus pennsylvanicus in the old field that had an exclusive home range (no overlap with the home ranges of other individuals); dates represent the middle of the trapping period; numbers in parentheses indicate the total number of home ranges*

Month	Males	Females
11 Sept.	0 (7)	60 (5)
10 Oct.	0 (5)	12 (12)
6 Nov.	50 (4)	100 (14)
4 Dec.	100 (4)	100 (3)
2 Jan.	—	—
6 Feb.	—	—
6 March	100 (4)	—
3 April	55 (9)	67 (6)
2 May	55 (9)	80 (10)
5 June	40 (10)	85 (13)
29 June	71 (7)	69 (16)
21 July	21 (14)	53 (15)
12 Aug.	57 (7)	88 (9)
13 Sept.	44 (9)	100 (10)

For the numbers of home ranges involved in the calculations, see Tables 1 and 2; the numbers are also the same as those utilized to determine the centers of activity.

The home range sizes of the males in the marsh were larger than those of the females (Fig. 1), particularly in the spring and summer (almost significant at the .05 level; $t = 2.000$ with significance at the .05 level requiring

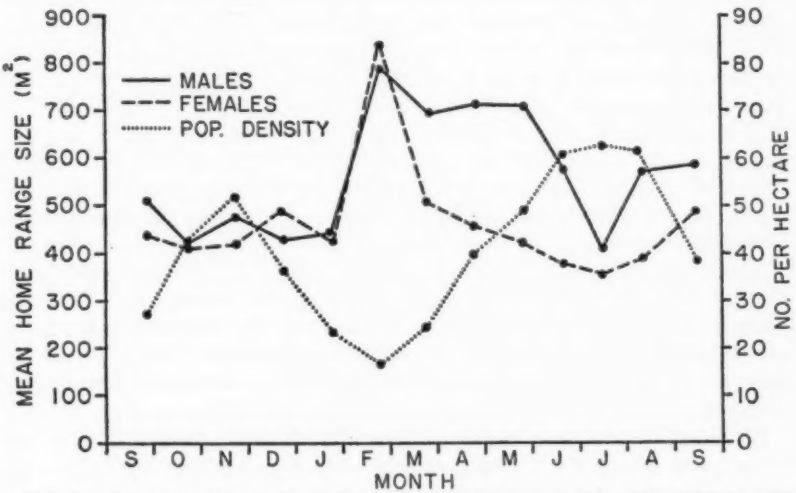

FIG. 1.—Home range sizes and population densities in the marsh, September 1957 through September 1958. For numbers of individuals involved, see Table 2.

TABLE 2.—*Percentages of Microtus pennsylvanicus in the marsh with at least a portion of their home ranges not shared with other individuals; dates represent the middle of the trapping period; numbers in parentheses indicate total number of home ranges*

Month	Males	Females
30 Sept.	93 (15)	93 (15)
27 Oct.	88 (26)	87 (38)
25 Nov.	86 (51)	82 (61)
22 Dec.	88 (43)	78 (40)
27 Jan.	80 (17)	95 (20)
24 Feb.	100 (15)	85 (14)
24 March	84 (31)	90 (19)
21 April	93 (33)	96 (54)
26 May	94 (34)	96 (51)
20 June	87 (48)	86 (67)
12 July	87 (47)	91 (56)
6 Aug.	90 (62)	94 (68)
6 Sept.	95 (23)	93 (33)

a t value of 2.056). Breeding in the marsh occurred primarily during the periods of October through November and April through June (Getz, 1960). The differences in sizes of the home ranges between the sexes may, therefore, be related in part to reproduction—the care of the young restricting the range of activity of the females. Also the males may be more actively engaged in searching for mates, resulting in larger apparent home ranges.

The mean monthly home range size of the males in the old field was significantly larger (at the .05 level) than that of the females (Fig. 2). The sizes for January and February are interpolations as the individuals on the area during these two months were not captured frequently enough to determine home range sizes. It is assumed that their range of activity during these months was less than the area sampled by a single trap (144 m^2).

The mean monthly home range of the females was significantly larger in the marsh than in the old field (at the .05 level). This differs from the data presented by Blair (1940) suggesting that individuals in areas in which the vegetation was more sparse had larger home ranges. There was no significant difference between the home ranges of the males in the marsh and old field.

There was an inverse relationship between population density and home range size for both sexes in the marsh (Fig. 1). This indicates that the home range sizes are affected by population pressures, the competition for space (as indicated below, food does not appear an important factor) becoming more acute during high population densities. Such a relationship has recently been documented for *Peromyscus leucopus* (Stickel, 1960).

There appears to be a direct correlation between population density and home range size in the old field (Fig. 2). This probably results from a response to environmental conditions. Because of sparse cover in the old field, temperatures are extremely high in summer and low in winter. During January

and February (the months having the lowest temperatures) the voles remained very close to their burrows (old mole runs in this case) or surface nests, foraging for only short distances. Their home ranges during these months were estimated to have been less than the area sampled by a single trap. In summer, when surface temperatures were very high during the day, the voles adopted a nocturnal activity pattern in place of their normal 24-hour pattern and home range sizes were not greatly affected.

Population density in the old field apparently did not become great enough to significantly influence home range sizes. In June, there was a slight decrease in population density and at the same time an increase in the home range sizes. This increase may be related to the decrease in population density, but the differences were not great enough to be significant.

Blair (1940) stated that a smaller food supply in the more sparsely vegetated areas resulted in larger home ranges than in areas where the vegetation was more abundant. However, the smaller home ranges in the present study actually occurred in the area with less vegetation, so that food did not appear to be the major factor determining home range size. The reduction in home range size in the old field during the winter was undoubtedly a response to unfavorable environmental conditions. The increase in home range size in the spring (at the same time the population density increased) evidently resulted from the more moderate environmental conditions that permitted wider foraging by the voles.

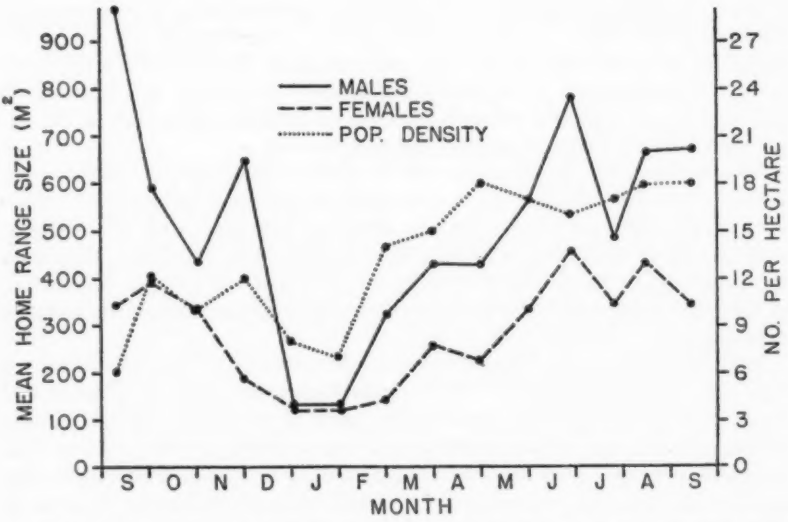

FIG. 2.—Home range sizes and population densities in the old field, September 1957 through September 1958. For number of individuals involved, see Table 1.

TERRITORIALITY

The term "territory" as used in this paper refers to that portion of the home range of an individual that is defended from intrusion by other members of the species of the same sex. This may range from defense of the entire home range to only some specific portion, such as the nest or feeding station. It might reach an extreme form in the defense of only the ground upon which an individual is standing at the time of an encounter. This latter condition can more accurately be defined as agonistic behavior (Scott, 1956) since it does not involve defense of a more or less permanent place within the home range. Crowcroft (1955) and Yerger (1953) have given evidence of territorial defense in small mammals (*Mus musculus* and *Tamias striatus*, respectively). Such behavior has not been demonstrated in most species of small mammals, however.

Food and shelter are probably the more important requirements of small mammals (Burt, 1940). If territoriality is displayed by a species, one would expect it to involve at least one of these factors. In the case of voles in the marsh (the area from which most of the data dealing with territoriality were obtained) neither food nor shelter would be expected to play important roles in territorial behavior; both were available in the form of grasses and sedges over the entire area. Potential nest sites and feeding stations, in the small hummocks of sedges, also were available in all portions of the area. Once established, these structures, especially the nest sites, might be defended.

Direct observation, particularly of encounters between different individuals, is the most accurate method of determining territorial behavior. Information obtained from traps placed in a grid pattern normally will not define the boundary of a territory. From such grid trapping, however, one can obtain certain indications (it is emphasized that only *indications* are intended in this paper) of territorial behavior as well as possible differences in its expression between sexes or at different seasons.

Five methods of analysis were used to obtain indications of territorial behavior: (1) determination of the percentage of exclusive home ranges (those not overlapping with home ranges of others of the same sex); (2) the percentage of individuals whose home ranges were at least partially exclusive for the same sex; (3) the distances between the centers of activity; (4) distribution of the centers of activity; (5) sexes of the individuals involved in multiple catches.

In the marsh, a greater percentage of the females had exclusive home ranges than did the males (Fig. 3). The only exceptions occurred in October and April, months during which breeding and birth of young were at a maximum (Getz, 1960). The exclusiveness of the home ranges of the females was, therefore, not necessarily related to the periods of breeding. This was further indicated by the high percentages of exclusive home ranges during the periods when breeding had ceased or was very low (December through March and July through August). That females with established home ranges outnum-

bered the established males during most months tends to add greater significance to these data.

In the old field, there was also a greater percentage of exclusive home ranges for females than for males (Table 1). There was no indication of a correlation of exclusiveness of the home ranges with the breeding seasons. In general, there was a greater percentage of exclusive home ranges in the old field than in the marsh (especially among the females), a result of the less dense population in the old field.

Those individuals whose home ranges were partially exclusive (a portion not shared with another individual of the same sex) could possibly display territoriality; conversely, those whose home ranges were entirely within those of others might not have a defended area. Almost all individuals in the marsh had partially exclusive home ranges for the same sex (Table 2). There was no relationship between population density and the percentage having unshared portions of their home ranges. If there were no display of territoriality, one would expect a greater percentage of completely overlapping home ranges to occur during the months when the population densities were highest. This did not occur. During the winter, months when the density was lowest, the voles were concentrated in a few more favorable sites in the study area. Even at this time there was no noticeable decrease in the individuals that had exclusive areas within their home ranges. Although these indications of territorial behavior were obtained, no sexual or seasonal differences were apparent.

If the environment of the study area were uniform, statistical treatment of the distribution of the centers of activity (Hayne, 1949) might determine whether or not territorial behavior was displayed. The environment was not

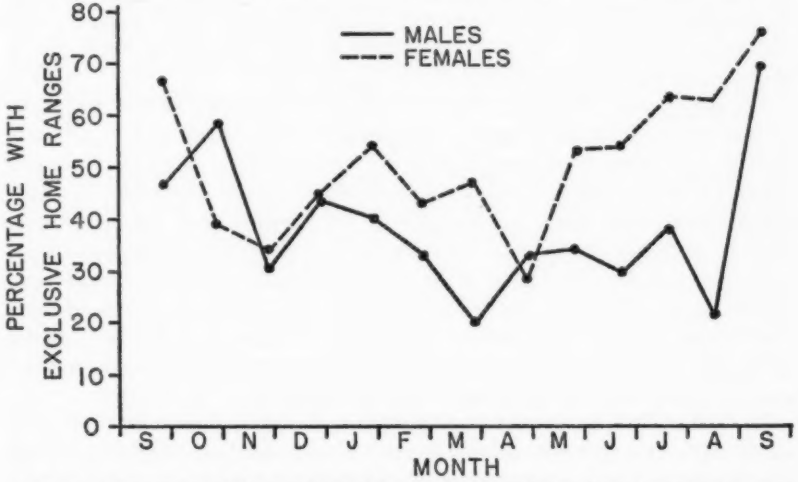

FIG. 3.—Percentages of the marsh population that had exclusive home ranges. For numbers of individuals involved, see Table 2.

uniform; therefore, the data concerning the centers of activity have been analyzed in a subjective way to determine any possible indication of territorial behavior. Only data from the marsh have been included in the following discussion.

If a relatively large portion of the home range were defended, the minimum distance to the nearest neighbor of the same sex should give an indication of its size (particularly during the periods of high population density). Centers of activity closer than 3 meters were rare among the males, but centers this close occurred most of the year, except during the winter months when the population densities were low. The spring and summer data concerning the females show that few centers of activity were closer than 7 meters. Centers only 3 meters apart were common in the fall. It thus appears that, if territorial behavior exists, the territories of the females may be slightly larger than those of the males.

Under conditions of equal population densities one would expect the nearest neighbor to be of the same sex about half the time, if territorial behavior were not displayed. If such behavior were displayed, however, the majority of the nearest neighbors should be of the opposite sex (providing population densities were high enough so that all of the habitat were utilized). There were 10 months when population densities were considered high enough to be utilized for this analysis. The numbers of established individuals of each sex were not equal, so the data had to be adjusted to determine departures from the expected. The females had only two departures from a 50-50 ratio. During these months, a majority of the females were closer to males, indicating possible territorial behavior. The males show four departures from the expected. During three months the majority of the males were closer to other males; only during one month were they closer to females. It thus appears that this method of analysis gives only a slight indication of a greater development of territorial behavior in females than in males.

The distribution of the centers of activity can also be utilized to determine indications of territorial behavior. In a uniform environment, the distribution (number per unit area) should approach uniformity, if territorial behavior is displayed. A random distribution would indicate no such behavior. As stated above, the environmental conditions were not uniform over the study area. Even in those portions in which the environmental conditions appeared most nearly uniform, the distribution of the centers of activity tended to be clumped. It thus appears that, if such behavior occurs, the defended area is of such a small size that it is not a factor in the local distribution of the vole. If the defended area were larger, individuals undoubtedly would have been crowded out into the unoccupied portions of the apparently favorable habitat.

Analysis of double captures (two animals in a trap) of adults indicates that mixed captures (one male and one female) account for half (Table 3). There were, however, twice as many instances of two females being captured as there were of two males. This indicates that males may be less tolerant of other

TABLE 3.—*Double captures of Microtus pennsylvanicus in the marsh*

Month	Male+Female	2 Males	2 Females
Sept.	5	0	0
Oct.	5	0	9
Nov.	16	8	15
Dec.	5	6	7
Jan.	7	0	4
Feb.	1	2	0
March	2	0	2
April	5	0	0
May	9	1	2
June	6	2	3
July	4	2	3
Aug.	10	4	4
Sept.	5	0	0
Total	80	25	49

males; it is contradictory to the indication above that females display territorial behavior to a greater extent than males. However, it is possible that, while territorial behavior in males may involve the defense of a smaller area, they display more agonistic behavior in regard to individual encounters than do the females. Too few double captures were obtained in the old field to indicate that the males avoided entering a trap already occupied by another male.

The various methods of analysis, therefore, indicate that *M. pennsylvanicus* may exhibit territorial behavior. They further indicate that such behavior is more pronounced in females than in males, and that the defended area of the female may be larger than that of the male. Neither sex shows any relationship between degree of development of territorial behavior and the breeding season, nor does it appear that population density has much influence on such behavior.

MOVEMENT

Data concerning those few individuals that shifted their home ranges were analyzed to see if a relationship existed between movement and population phenomena. Centers of activity were determined for each individual each month. Only those individuals that had shifted their center of activity outside the home range of the previous month were considered to have moved. The straight-line distance between the two centers of activity was taken as the distance of movement.

Except for the months of October and November, a larger percentage of males than of females shifted their home ranges (Fig. 4). The greater movement of males preceding and during the spring breeding season may be a result of their moving about more in search of mates. Miller (1958) found that male *Apodemus sylvaticus* moved about more during the breeding season than at other times. In the present study, movement was not greater during

the fall breeding season. This cannot be explained. The home range data, as given above, support the movement data. Home ranges of the males were larger during the late winter and spring, indicating more activity. There was little or no difference in the home range sizes of the two sexes during the fall.

Movements of subadults were compared with those of adults. Young animals in search of areas in which to establish themselves have been considered responsible for most of the movement in a population (Blair, 1953). Burt (1940) stated, however, that in some species the mother may move, leaving the old territory for occupancy by the young.

The animals designated as "subadult" for the most part had not moved far from their nests when first captured (many were taken in the same trap with their mothers). By the time of the second month of capture, they were sexually mature; if they were going to occupy a new territory, they should have done so by this time. Subadults were captured in the marsh only during the months of September through November and May through August. Movements of adults used for comparison were determined only for those individuals present during these months. Of the 99 subadults that could be used to obtain movement data, 19 (19 per cent) shifted their home ranges. Of the 630 adults available for comparison during the same months, 75 (12 per cent) shifted their home ranges. Is is therefore apparent that, even though a slightly greater percentage of subadults than adults shift their home ranges, the majority of the subadults do not move their home ranges before reaching sexual maturity. Many of the females, as a result, apparently construct a nest within the home range of the mother. Howard (1949) also found this to be true

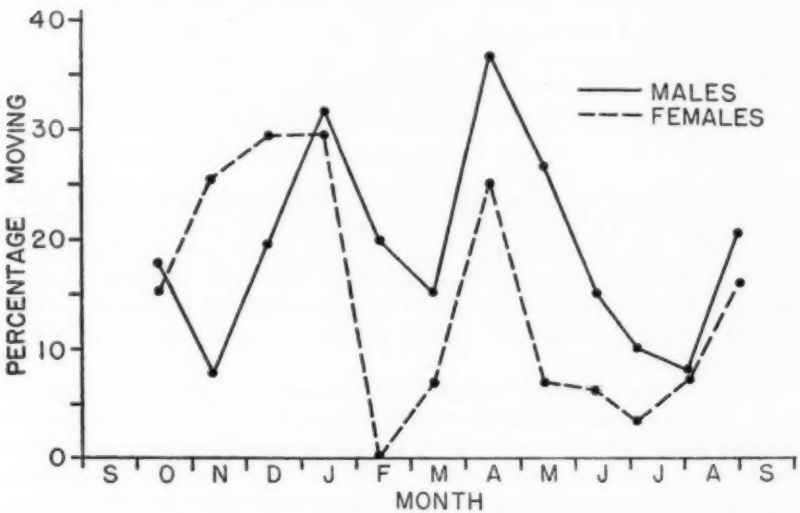

FIG. 4.—Percentages of the marsh population that shifted their home ranges.

of *Peromyscus maniculatus bairdi*. Godfrey (1953) likewise found that young *Microtus agrestis* did not move far from their place of birth.

DISCUSSION

The results of the present study indicate that in the more favorable habitats, i.e., those with suitable cover, food, and moisture conditions, higher densities of *M. pennsylvanicus* may result in smaller home ranges. It was also found that female meadow voles have smaller home ranges than do males. There were indications that such smaller sizes might be related to the breeding season. This would agree with Howell (1954) who found female cotton rats to have smaller home ranges during the breeding season. Brown (1956) also found female *Microtus agrestis* to have smaller home ranges, but indicated no correlation with the breeding season.

If traps are widely spaced, samples of population densities at different seasons, obtained from a similar trap arrangement, will show less differences than actually exist. When the home ranges are smaller, each individual will come in contact with fewer traps (resulting in fewer captures) than when the home ranges are larger. To partially eliminate such biases, the trap interval must be small enough so that there is at least one trap (preferably more than one) per unit area equal to the smallest home range size displayed by either sex of the population. In regard to *M. pennsylvanicus*, the results of the present study indicate that, for a grid type of distribution of traps, 10 to 12 meters is the maximum interval allowable if each home range is to be sampled. An interval of 6 to 8 meters probably would be more desirable, especially when short trapping periods (3 to 4 days) are used.

Although evidence indicated that the meadow vole displays territorial behavior, it appears to be less developed than in such species as *Peromyscus leucopus* (Burt, 1940), *P. polionotus* (Blair, 1951), and *Tamias striatus* (Yerger, 1953). The size of the defended area is small, probably not more than 7 meters in diameter. Population densities seldom reach a point where there would not be at least this much space per individual. As a result, it seems doubtful that territorial behavior per se would cause the emigration of individuals or influence the local distribution of *M. pennsylvanicus*. It is possible that there may be a minimum home range size tolerated, after which further increase in population density will result in movement out of the area. The data concerning movement within the population show that such a density was not attained by the population during the period of this study. During periods of high population densities, the individuals were clumped within the apparently favorable portions of the study area. While there may have been microenvironmental factors involved in the avoidance of certain sites, it seems more logical that population densities did not reach a point where space became a factor in their distribution.

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BEHAVIOR OF SALT-MARSH *MICROTUS* DURING WINTER HIGH TIDES

By George F. Fisler

Abstract: The populations of *Microtus californicus* inhabiting the salt marshes of the San Francisco Bay region are subjected to daily high tides but extremely high tides, which completely submerge most vegetation and thus force mice from cover, are encountered only in winter. The mice are in considerable danger from both drowning and avian predation at this time. During these high tides, mice hide in what emergent vegetation remains, swimming freely on the water surface as little as possible. However, swimming and diving abilities are well developed. Evidence presented shows that *Microtus* usually remain on their home ranges during and after these very high tides, and it is concluded that only the rare, combined effects of wind, rain, and the several factors that produce high tides will displace a population, or reduce its size, to any great extent.

The California vole, *Microtus californicus,* is a common inhabitant of the salt marshes of the San Francisco Bay region. Large areas of these marshes are subjected to daily tidal submergence, but normally these tides are not sufficiently high to submerge completely the marsh vegetation and thus force resident mammals from protecting cover. In the period from November to January, the combined effects of extremely high tides, wind, and rain can increase the depth of some tides by as much as 5 feet above the mean higher high tide. Although extremely high tides also occur in June and July, they are not critical to adult mice because there is little augmentation of the tide by wind and none at all by heavy rain or increased inflow from the Sacramento and San Joaquin rivers. It is during the winter period of diurnal high tides that small mammals are forced from cover and actually swim about in open water. This fact has been noted by Sibley (1955) and Johnston (1957). However, no detailed account has been given of the manner in which *Microtus* adjust to these tides, although Johnston observed the swimming and diving ability of this vole and speculated on its other marsh adaptations. The present author was afforded the opportunity to observe these reactions in the course of a study of salt-marsh *Reithrodontomys* when all mice captured were marked for observations of movements. This report chiefly concerns the high tides of 26–30 December 1959 and 25–27 January 1960, but reflects information gained throughout 1958 and 1959. Observations were made primarily at San Pablo salt marsh, near Richmond, Contra Costa County, California.

HABITAT

Salt marshes of the San Francisco Bay region contain three important emergent plant species: *Salicornia ambigua, Grindelia cuneifolia,* and *Spartina foliosa.* Of these, the former two are quite bushy in growth habit and provide dense cover to a height of 1 to 4 feet above the ground. *Grindelia* grows somewhat taller than *Salicornia* and is the only important marsh plant the tips of which are unsubmerged during most of the extreme high tides. During

normal high tides, these plants are flooded only to a depth of an inch or two, and adult mice living in the marsh at this time are neither threatened with drowning nor forced from adequate overhead cover. *Spartina* is not important as a cover plant for *Microtus* because few, if any, mice utilize areas where it grows. Mice in salt marshes are concentrated about the natural levees of the tidal sloughs. This is presumably in response to the greater cover provided there by *Grindelia* and the thick, tall *Salicornia* plants.

REACTIONS TO HIGH TIDES

When water thinly covers the marsh, no obvious movement of mice can be detected, but as the water level rises, *Microtus* can be seen climbing up into the *Salicornia* and *Grindelia*. They are still very hard to observe as they invariably remain well concealed in the vegetation just above the rising water level. When the tide reaches its highest point, some vegetation is usually still emergent, and it is here that the mice hide. *Microtus* sit in a humped-back position with their tails tucked under the body. For the most part, these mice are completely dry. Occasionally mice are found sitting on boards (with "seeming nonchalance," Johnston, 1957) or concealed in crevices and under bark of floating logs. *Microtus* are quite tolerant of one another during this period. Individuals will stay within a few inches of each other in the emergent vegetation or they may even be huddled together in the crevices of logs. Only one instance of intraspecific conflict was noted. When one *Microtus* reached a log already occupied by two others, one of the latter bit the interloper several times but soon desisted and allowed the swimmer to crawl up on the log. As Johnston (*loc. cit.*) noted, free-swimming mice were uncommon, although several were observed. It is likely that the majority of these swimming animals had been forced from their place of refuge by other mice or by the still rising tide.

When an observer approaches, *Microtus* rely on three methods of escape. First, the mouse may scurry away through the adjacent emergent vegetation, attempting to reach more distant cover where it can hide again. This procedure is followed when mice are fairly well hidden and are in large patches of emergent vegetation. The second method, diving, is utilized commonly when cover is thin or absent. Variations of the diving reaction occur. Rarely, the mouse will simply pull its head slowly under the surface, instead of using the forward lunge of the regular dive, and swim away after it sinks 2 or 3 inches under the water surface. A few times mice were observed actually crawling headfirst down the branches of the cover plant, submerging while crawling on the stalks, and then pushing away from the stalk when several inches under water. These latter two methods of submerging make it quite difficult to detect mice in thick cover. The third method of escape is surface swimming. Here the animal launches into the water and swims rapidly away through the open water or between the emergent plants. More detailed accounts of swimming and diving are given beyond.

Diving and underwater swimming.—*Microtus* dive with ease and quickness. Rarely is sufficient air trapped in the fur so that the animal is forced to the surface. Since no *Microtus* were observed diving except under duress, this reaction, then, is used only as an escape mechanism. Ability to change direction under water is not marked, but occasionally they will veer off as much as 90° from the original course. This is a response to underwater obstacles rather than any active attempt to change directions to confuse a pursuing predator. *Microtus* do make good use of submerged cover, however, diving beneath the *Salicornia* mat or crawling through and under whatever protection is available beneath the surface. The diving animal can probably see where it is going under water, as the eyes remain open in the course of the dive and subsequent swimming. No collisions with underwater obstacles were observed.

The duration and distance of the dive varies with the situation. Johnston (*loc. cit.*) stated that they rarely dived longer than 10 seconds and could swim up to 10 feet under water in that period of time, but I found that, hard pressed, they remained submerged up to 20 seconds and could swim distances of 15 to 22 feet. After surfacing from one of these prolonged dives, they appear exhausted and will not dive again for several minutes. During this period they can easily be lifted from the water without struggling to escape. After shorter dives, *Microtus* seem to be quite strong and will quickly dive again if necessary. I have pursued them so that they have been forced to dive four times in rapid succession, but these submergings were of only 3 to 5 seconds duration. More frequently, repeated diving is interspersed with surface swimming or running through emergent vegetation. *Microtus* regularly dive to a depth of one foot or until underwater cover is reached. On one occasion, a *Microtus* swam a 40-foot slough, diving to a depth of more than 4 feet and swimming about 22 feet under water. No attempts to submerge in one place and remain there, surfacing *in situ*, were observed.

Surface swimming.—*Microtus* are strong swimmers as long as they are not exhausted by diving. They swim with the front feet tucked under the body, tail trailing and apparently useless, and pump hard with their hind legs and feet as well as their hips. As the tail is not employed as a rudder, turning is accomplished only by a violent twisting of the body.

Often *Microtus* must swim through rough water or strong tidal currents. One occasion of rough water occurred when a wind of 25 mph swept over the flooded marsh. Waves 2 and 3 inches high lapped at the stranded mice. I saw no instances of animals washed from their shelter, but occasionally one would strike out voluntarily, perhaps in search of a better position. These individuals returned to their original hiding place if, as frequently happened, they did not encounter a suitable place within 20 or 30 feet. They experienced little difficulty remaining upright but were obviously straining to swim against the waves. I suspect that higher waves would prevent mice from changing their places of shelter without danger of drowning and would completely swamp any swimming mice in areas of no emergent vegetation.

Several mice were observed swimming against tidal currents. Against a surface flow of about 3 feet per second, *Microtus* could make good headway, but they preferred merely to maintain their position or angle to the nearest foothold. Reactions to any stronger tides were not observed. However, in all probability, this represents the fastest flow encountered normally (see Stevenson and Emery, 1958: 12).

Drowning.—Johnston (*loc. cit.*) noted the large number of small mammal carcasses found throughout the marsh after each series of high tides. This was also noted by the present author during the months of February and March 1959 and February 1960. Since the mice are subjected to high winds and strong currents during these high tides, it is reasonable to conclude that many animals drown at this time. Three dead *Microtus* found after high tides did have their lungs filled with water. Certainly many mice must drown in the occasional high tide that inundates all the marsh vegetation.

Predation.—The flooded marsh is regularly patrolled by marsh hawks (*Circus cyaneus*) and short-eared owls (*Asio flammeus*). In the course of my observations, at least four hawks and seven owls were hunting over the 200 or so acres involved. Actual observations of predation include three occasions when short-eared owls took swimming mice (presumably *Microtus*) from open water. A catwalk extends across the entire marsh at this locality and the mammal entrails left there bear silent testimony to the fact that many mice are taken in the course of the winter high tides. There is assuredly no decimation by mammalian predators at this time. The mice are exposed from about ½ to 2 hours or more depending on the height of the tide and the rapidity of the flood and ebb tides.

DISPLACEMENT OF MARKED INDIVIDUALS BY HIGH TIDES

Johnston (*loc. cit.*) writes that mammal populations remain in nearly the same locations during high tides. What is true for the population as a whole is also true for the individual. This tendency to remain within a restricted area is evident when a *Microtus* is pursued during a high tide. Usually one cannot force an animal beyond a certain point for it will turn and swim back past the observer. Successful maintenance within its home range during a high tide is of considerable importance to the population, as concentration of animals in a narrow high zone in the marsh might cause conflicts later when the tide recedes. If animals remain in their home ranges, energy will not be wasted on increased intraspecific competition for space because of the displacement of large segments of the population to unfamiliar areas.

In my study area a total of 25 *Microtus* had been marked prior to the especially high tides of the winter of 1959–60. Of these, it is estimated that 13 were either dead or had moved before the tides occurred. It is known that there were still many unmarked animals on the area (Lincoln index method), for live trapping before the high tides averaged only about 52 per cent recaptures (Table 1). During the high tides, when many more individuals were marked, this recapture percentage averaged about 59. The average recapture

TABLE 1.—*Recapture percentages of a marked population of Microtus*

Date	Captured by	Recaptures	New	Recapture percentage	Average recapture percentage
21 Oct.	Live trap	–	3	–	
22		1	7	12.5	
23		5	5	50.0	
24		5	5	50.0	52.4
19 Dec.		2	1	66.7	
20		3	4	42.9	
29	High tide	4	3	57.1	59.1
30		11	7	61.1	
4 Jan.	Live trap	3	1	75.0	
5		7	1	87.5	73.5
6		7	2	77.8	
7		7	6	53.8	
26	High tide	3	0	100.0	
5 Feb.	Live trap	5	1	83.3	
6		6	0	100.0	91.6
7		5	1	83.3	
8		4	0	100.0	
15 Mar.		1	0	100.0	
16		5	2*	71.4	
17		1	5†	16.7	
18		6†	1	85.7	

* Individuals were juveniles 4 to 6 weeks old and therefore raised since the February trapping period.
† Includes three juveniles.

percentage after the first six tides (November and December) was 73.5. After the last three high tides in January, the average percentage, for the February trapping period only, was 91.6. I therefore assume that, since this average recapture percentage did not fall at any time during this four-month period, the influx of animals into the area was negligible; that is, the individuals present originally, for the most part, remained on the area and only the normal replacement of mice occurred. The tides did not bring in new mice which settled on the area. Only one case is definitely known of a *Microtus* leaving the study plot for adjacent areas, and this individual was forced out during a high tide by the observer.

Table 2 contains records for individual *Microtus* with a significant number of recaptures to illustrate maintenance in the same area through varying numbers of high tides. One can ascertain from this table that 16 of 18 individuals were displaced 120 feet or less. Another individual was in a location 240 feet from its original home area. The last mouse moved 700 feet but had done this between the last high tide (27 January) and the next trapping period (5 February), a span of nine days. This animal, a male at least four months old, was not moved by high tides.

The estimated displacement figure in Table 2 was derived by first assuming that the original point of capture was close to the center of activity of the individual. The figure was then based on the distance the mouse was caught from the original capture station on its last one or two captures. Although this

TABLE 2.—*Displacement of 18 marked Microtus by high tides*

No. and sex	No. of captures	Total days known on area	High tides endured	Greatest distance moved, ft	Estimated displacement* ft
58♀	7	146	9	120	0
48♀	10	110	9	320	240
110♂	5	50	8	160	40
111♀	5	87	8	40	0
41♂	4	79	6	40	0
46♂	5	77	6	200	0
47♂	6	78	6	280	120
61♀	3	74	6	120	120
63♂	3	75	6	200	100
52♂	4	69	4	80	0
114♂	4	9	4	0	0
122♂	9	41	4	720	700*
123♀	4	41	4	40	40
116♂	2	3	3	0	0
119♀	3	3	3	0	0
120♀	5	9	3	80	0
131♀	4	74	3	0	0
138♀	4	70	3	120	0

* See text.

method of analysis is subjective as to whether the first capture is near the center of activity, it does illustrate the fact that while some mice were captured at great distances from the original capture station, they returned to this area of first capture. Table 2 shows that 11 of 18 animals either returned to or were never captured away from the original point of capture. One individual (No. 46♂) was once caught 200 feet from its original point of capture but was retaken at that place later on. Two mice were taken 120 feet from their original capture station but subsequently returned there. Three other *Microtus* were captured at distances over 120 feet from the initial capture station but also returned to their original home areas although not to the original capture station. Four of the preceding six animals were males, but the evidence does not suggest that differences in distances moved are attributable to the sex of the individual.

Brant (1953, MS), in his work on rodent populations of the Berkeley Hills east of San Pablo salt marsh, considered that the best estimate for the average maximum distance between points of capture of *Microtus* was 60 feet. This figure was derived from data gathered on grids of 0.4 and 3.1 acres with traps placed 10 and 25 feet apart, respectively. These small grids were located within a 28-acre plot. Using data from this latter, where traps were spaced 50 feet apart, the average maximum distance between captures was 120 feet. Preference was given to the first-cited figure because of Brant's belief that the greater distance between traps gave only data for the mice with exceptionally large home ranges and would not detect smaller ones. My traps were placed at intervals of 40 feet along a slough in a line extending 1240 feet.

Salicornia and *Grindelia* were the dominant plants in the middle one-third of the line, while *Salicornia* and *Distichlis spicata* were the commonest in the remaining areas. This trapping system should, then, be adequate to detect mainly the larger home ranges. Since a grid was not used, the extent of the home ranges away from the slough was not determined. Other *Microtus* marked in the study area were not trapped more than once or twice, and these presumably represent the animals with the smaller home ranges. Traps set for *Reithrodontomys* caught more of that rodent than of *Microtus* only in the middle one-third of the line, an area more favorable for *Reithrodontomys* than either end. Thus the possibility of capture of *Microtus* in the middle one-third of the line was reduced considerably. The 18 animals included in Table 2 were mostly taken in the first and last one-third of the line, that is, in the area of greatest possibility of recapture of *Microtus*. This also explains in part why many *Microtus* were not recaptured. Predation and other decimating factors, such as drowning, certainly must have removed some marked *Microtus* from the study area.

The evidence presented here clearly shows that voles tend to remain within their home ranges during the high tides of the winter season, even when most of the marsh vegetation is submerged. However, it should be pointed out that these mice almost always have a high place in their home range on which some vegetation remains emergent. This allows the animal to wait out most tides in a place of relative safety. But it does sometimes happen that the combination of high wind and heavy rain, in conjunction with the high tides of November to January, increases the depth of the water so that all the marsh plants except the highest tips of *Grindelia* are covered. In such a circumstance, it would seem almost impossible for the mice to remain in one location, especially if the high water is accompanied by a strong wind. The frequency with which these conditions occur is not known, as their effect on each individual marsh varies with the local weather and marsh characteristics. Ordinarily, however, *Microtus* are capable of remaining on their home ranges through the winter high tides and thus can successfully maintain the adult population in the marshes during this critical period.

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AGE VARIATION IN PHENACOMYS

By J. Bristol Foster and Randolph L. Peterson

Abstract: Attempts were made to ascertain the age of a wild-caught *Phenacomys ungava*, within rather close limits, by comparing its skull with those of a series of known-age phenacomys. Such comparisons are not valid, since the laboratory voles do not develop exactly as do those in the wild. Rather, one may only comment that great care must be taken when comparing laboratory data with data gathered under natural conditions.

It is demonstrated that the rostrum of phenacomys continues to grow throughout the first year of its life and that this may be used in approximating its age more closely than has been hitherto possible. Degree of extension of teeth is also quite useful in calculating age.

A satisfactory method of determining the relative age of animals is often essential before more precise studies can be carried forward. Varying degrees of success have been achieved in establishing age criteria for small mammals. Ecke and Kinney (1956) worked with molt progression of *Microtus californicus*, Kirkpatrick and Barnett (1957) studied gray squirrels, Bond (1956) made some progress with beavers and Olsen (1959) used tooth wear on the dental pattern of muskrats as age criteria.

In connection with a broader study of *Phenacomys ungava*, we were able to assemble a workable series of specimens, including skulls of animals of known age that were born and raised in the laboratory, regular museum specimens, and skulls recovered from owl pellets. In total some 344 specimens were used in this study. Most of the specimens were secured from two localities, the vicinity of Authier-Nord, Quebec, and Fort Churchill, Manitoba (Smith and Foster, 1957). These specimens are now housed in the Royal Ontario Museum.

Recent authors (Hall and Cockrum, 1953; Hall and Kelson, 1959) have regarded *Phenacomys intermedius* as comprising all of the short-tailed forms, including *ungava*. This action is apparently based on Crowe (1943), who alleged that *P. i. levis* and *P. u. mackenzii* are shown to intergrade. A revisionary study is underway by one of us (Peterson). However, much more work must be done on the *intermedius* group before a final decision can be reached. Preliminary studies indicate that *P. i. levis* has been based on a high per cent of young specimens, which probably misled Crowe in his evaluation of the Alberta specimens from Entrance, Maycroft, Mud Lake and Muskeg Creek. Most of Crowe's specimens have been reexamined by Peterson, as well as the type and other pertinent specimens. The original Entrance specimens were not located; however, they were said to "display the well marked characters of topotypical *mackenzii*" and were subadults. The two Mud Lake specimens in the American Museum of Natural History are referable to *P. intermedius*. The one supposedly approaching *mackenzii* (No. 95166) is a full adult, apparently older than other *intermedius* material available to Crowe. This advanced age produces a relatively narrow infraorbital width and a more

depressed rostrum, a condition mentioned by Crowe (*op. cit.*) for the Maycroft, Alberta, specimen. The other Mud Lake specimen (No. 95168) which "is closer to *levis*" is a younger individual and is clearly *P. intermedius*. The U.S. Fish and Wildlife Service (National Museum) specimen No. 81489 poses a less clear picture. Apparently Howell (1926) originally referred to it as an aberrant colored individual of *mackenzii* with damaged skull and too young to exhibit pronounced characters.

While a final evaluation of the relationship between *Phenacomys ungava* and *P. intermedius* must await a more thorough study, especially of the latter, it seems quite obvious that intergradation between the two forms has not been demonstrated. On the basis of our present understanding, *P. ungava* always has a yellow nose when adult (but not as juveniles and only occasionally as subadults) while *intermedius* apparently never develops a yellow nose at

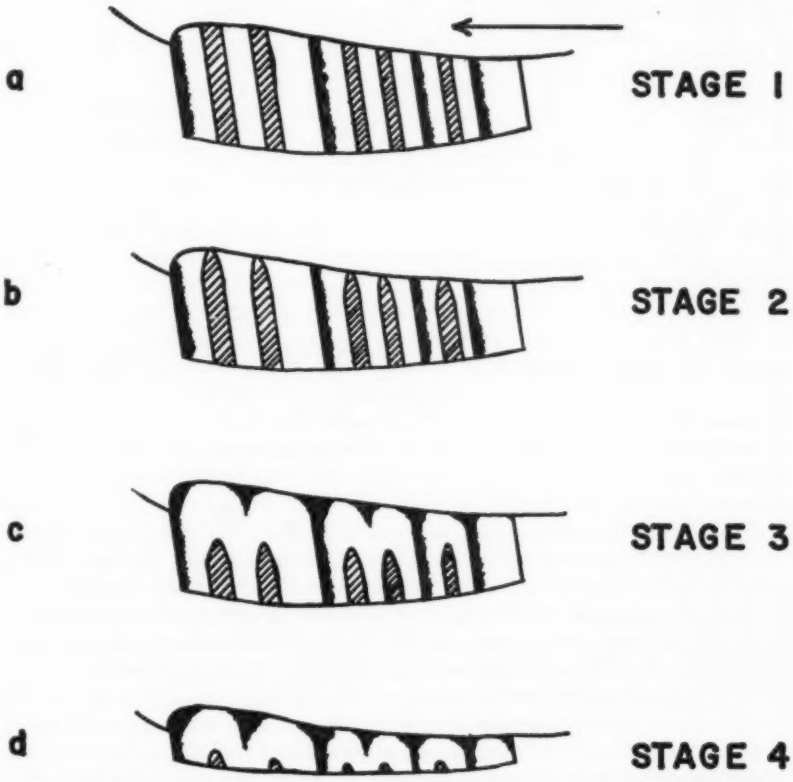

FIG. 1.—Diagrammatic representation of the development of the upper left molariform teeth of *Phenacomys ungava*. *a*, teeth not fully extended; *b*, teeth almost fully extended; *c*, teeth fully extended; *d*, teeth fully extended and badly worn.

any age. While there is much variation in color in both groups, *ungava* is characterized by a warmer, brighter brown, while *intermedius* is duller and more grayish brown. Cranially, *intermedius* tends to be smaller with a smaller auditory bulla and relatively wider interorbital width. The latter character varies with age and tends to constrict with advanced age in both species. It is therefore essential that critical comparisons be based on specimen of comparable age.

This work was supported in part by grants to the junior author from the National Research Council of Canada.

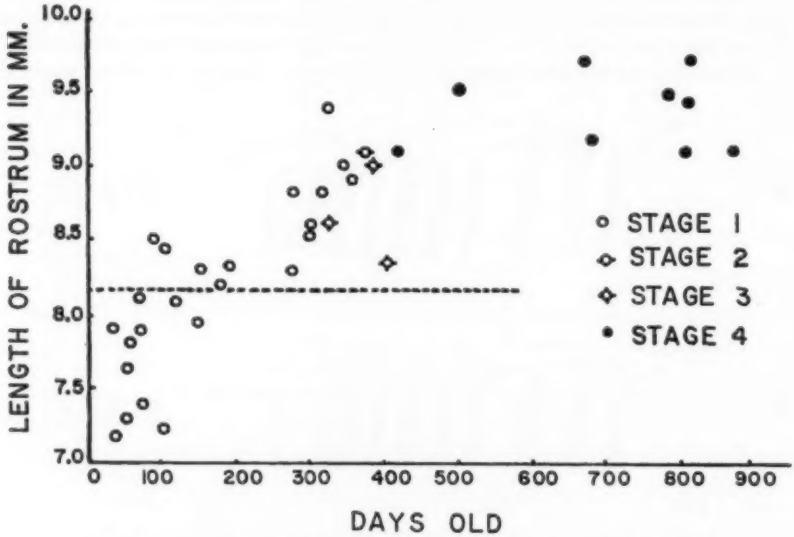

FIG. 2.—Increase in length of rostrum with age of phenacomys of known age.

GENERAL SKULL FEATURES

The skulls of *Phenacomys* resemble those of *Microtus* in general form. Phenacomys differs from many other microtines in that the teeth become rooted and cease growing when the root openings close. This provides a particularly useful aging character. The crania of juveniles, as compared with those of adults, appear to be weak, rounded, and unridged, while the bullae are relatively small, the incisive foramina shorter, the zygomata compressed, the interorbital region relatively wider, and the rostra shorter. Also, that portion of the molars beyond the alveolar border fails to show any indication of roots (designated as Stage 1, Fig. 1*a*). Roots may exist just below the alveolar border, however, or if the animal is sufficiently young, roots may be as yet unformed. As the tooth extends, the roots develop and the crown is worn off until the base of the roots is just visible above the alveolar border. The teeth

may now be termed almost fully extended (Stage 2, Fig. 1*b*). The roots continue to grow, and the tooth continues to extend until, with increasing age, the basal openings of the two roots become entirely closed, after which the tooth extends no farther (Stage 3, Fig. 1*c*). The tooth continues to wear until, in advanced age, the crown is practically worn down to the roots (Stage 4, Fig. 1*d*).

TABLE 1.—*Length of the rostrum in dead-caught phenacomys from Ft. Churchill, Manitoba, and Authier-Nord, Quebec*

Locality	Age and Sex	No. Specimens	Av. length, mm.	Standard error
Churchill	Juv. ♂	41	7.30	0.083
"	Juv. ♀	75	7.36	0.046
"	Adult ♂	42	8.70	0.029
"	Adult ♀	30	8.98	0.058
"	Old Ad. ♂, ♀	11	9.34	0.217
Authier-Nord	Juv. ♂	33	6.91	0.072
"	Juv. ♀	18	6.96	0.078
"	Adult ♂	7	8.61	0.104
"	Adult ♀	8	8.55	0.054

THE ROSTRUM

Nine skull measurements were made from every undamaged skull taken at Fort Churchill and Authier-Nord, 1953–1956. These measurements include the condylobasal length, zygomatic width, length of rostrum (from front of incisor to alveolus of first molar), width of rostrum, length of nasals, length of palatine slits, length of molar toothrow, infraorbital width, and width of skull across the mastoids. The measurements of the length of the rostrum proved to be particularly useful, as elongation of this section of the skull displayed a close correlation with advancement of age while the other measurements did not. This tendency is shown in Fig. 2, where length of rostrum is plotted against age, for laboratory-raised animals. Here the rostrum increases rather rapidly in length for the first 150 days, and approaches maximum size at about one year.

The rostra of the wild animals also display increase in length with age. In Figs. 3 and 4, the rostral measurements for dead-trapped Ft. Churchill *Phenacomys* are plotted against date of capture. All of the 193 individuals were taken in the months of May, June, July, August and September. As may be seen, the specimens can be separated into two discrete groups. The lower group (juveniles) first appears about the middle of July, and has a rostral range from 6.0 to 8.2 mm (Av. 7.3). The upper group (adults) has a rostral length from 8.2 to 9.8 mm (Av. 9.0) and is present for the entire period. The critical length of rostrum for separating adults from juveniles is 8.2 mm. These two groups are significantly different in rostral measurements (Fig. 5). The members of the Authier-Nord population also represent two significantly

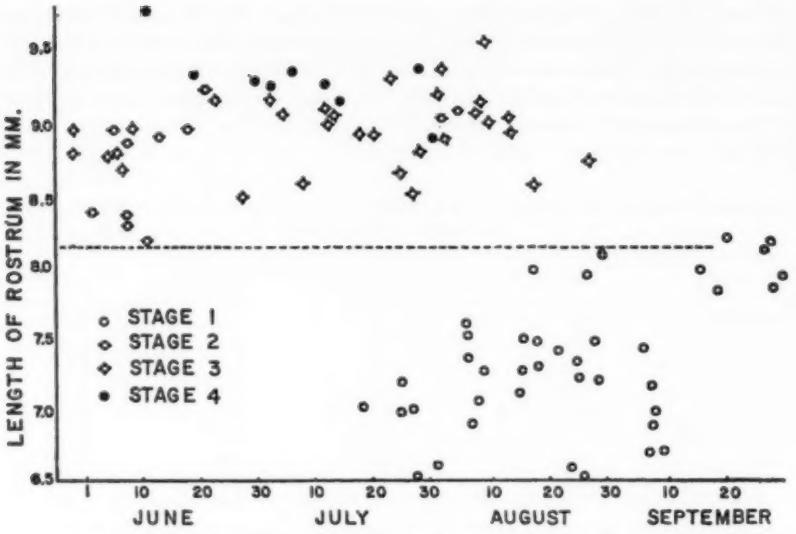

FIG. 3.—Length of rostrum, degree of extension of teeth, and date of capture of snap-trapped male phenacomys from Ft. Churchill. Adults above, juveniles below.

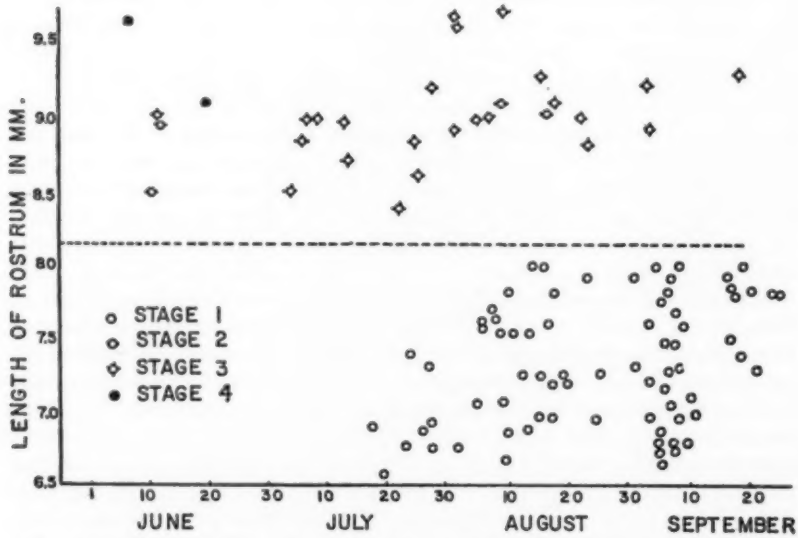

FIG. 4.—Length of rostrum, degree of extension of teeth, and date of capture of snap-trapped female phenacomys from Ft. Churchill. Adults above, juveniles below.

different groups, juveniles and adults (Fig. 5). The mean rostral length of both adults and juveniles of the Authier-Nord group is distinctly smaller than for their Ft. Churchill counterparts. The former were collected over four summer months, which may account for the difference, although it is possible that the difference might be affected by geographic variation. The length of rostrum does not differ greatly between sexes (Table 1).

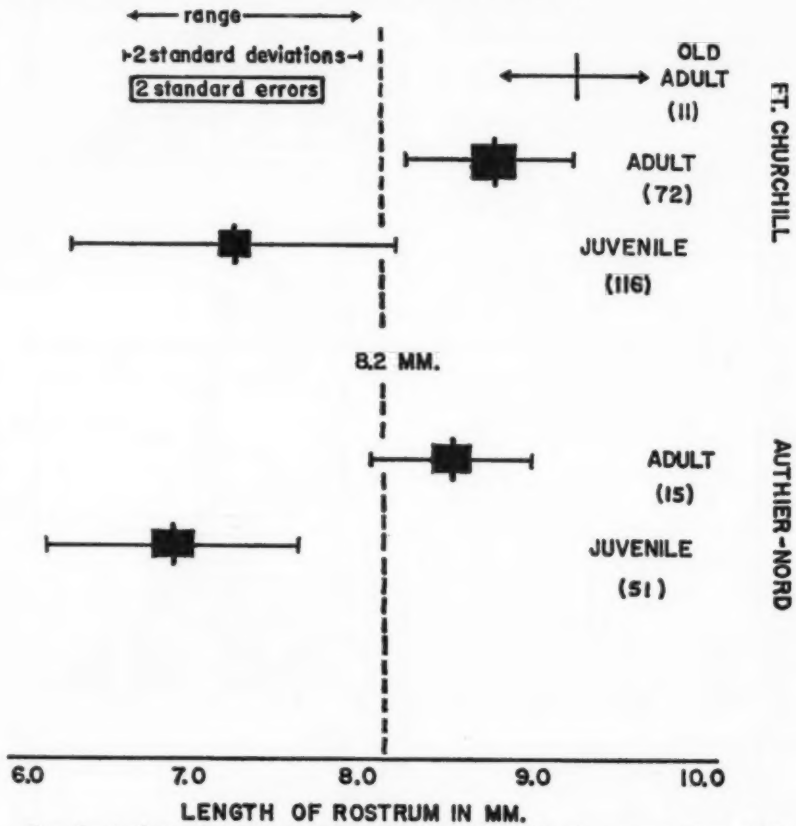

FIG. 5.—Analysis of rostral measurements for wild-caught phenacomys taken at Ft. Churchill, Manitoba, and at Authier-Nord, Quebec.

THE TEETH

The molar teeth of our phenacomys specimens may be classified as (1) not fully extended, (2) almost fully extended, (3) fully extended, or (4) fully extended and badly worn. These categories represent progressive stages toward old age, as is shown in Figs. 3 and 4, where all members of the lower group (juveniles) have Stage 1 teeth (Fig. 1), while all those of the upper

group (adults) have their teeth at Stages 2, 3 or 4. Forty-two per cent of those adults caught in May and June have Stage 2 teeth (the remainder being at a more advanced stage), while only 3 per cent of those caught in the combined

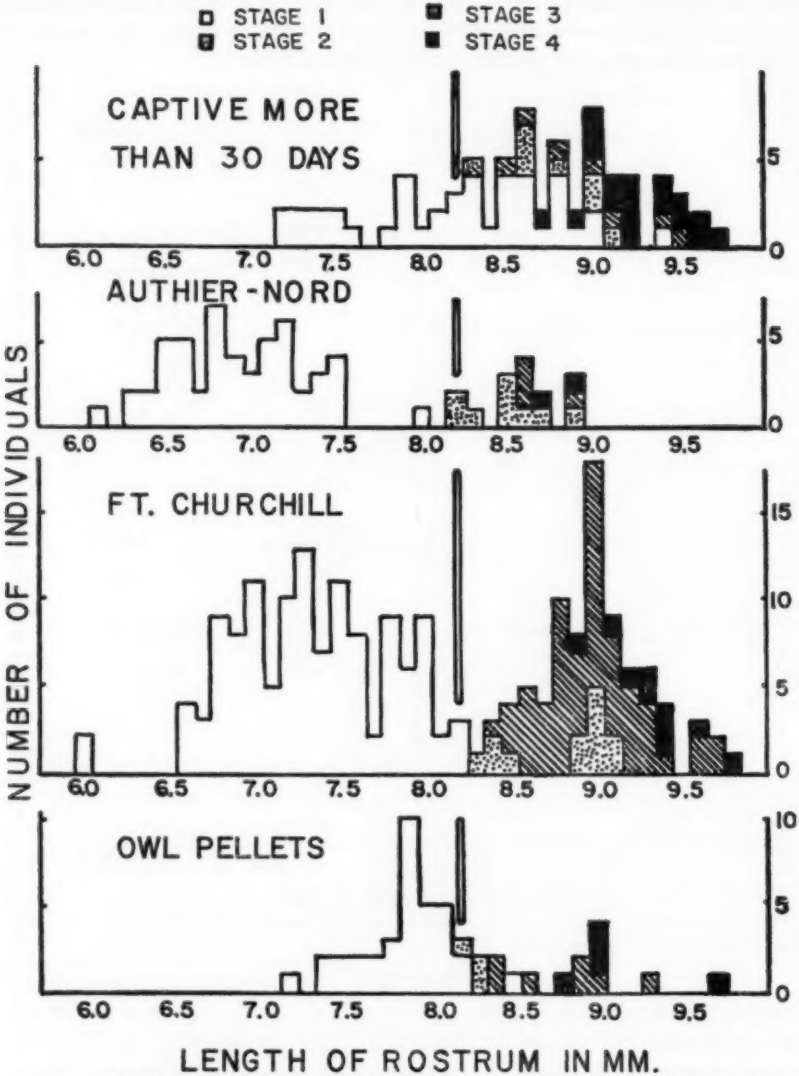

FIG. 6.—Number of individuals at each rostral length, showing degree of extension of teeth for those phenacomys kept captive for more than 30 days, those trapped at Ft. Churchill and Authier-Nord, and those found in owl pellets at Ft. Churchill.

months of July, August and September have teeth almost fully extended. It appears that at Ft. Churchill, the molar teeth of most wild phenacomys become extended in the spring (April, May, June) of their first year at an age of about 8 to 10 months and have a rostral length of about 8.2 mm by this time.

All adult Authier-Nord phenacomys displayed teeth at Stage 2, 3 or 4, while all of the juveniles showed Stage 1. These are, therefore, similar to the Ft. Churchill specimens in this regard. However, the laboratory-raised phenacomys varied from this pattern. In Fig. 2, there are numerous individuals with teeth at less than Stage 3 development well beyond the 8- to 10-month period indicated as the time necessary to reach this stage in the wild population. Also, there are many phenacomys with teeth below Stage 2, 3 or 4, yet beyond the 8.2-mm length of rostrum, an occurrence not found in the wild population.

Eleven phenacomys in the upper half of the adult group (Figs. 3 and 4) have Stage 4 teeth. Also, their rostra are generally longer than those of animals with Stage 3 teeth (Fig. 5). These specimens probably represent animals caught in their third summer.

DISCUSSION

Figure 6 summarizes the rostrum-tooth data gathered at Authier-Nord, Ft. Churchill and the laboratory. The number of individuals is shown for the

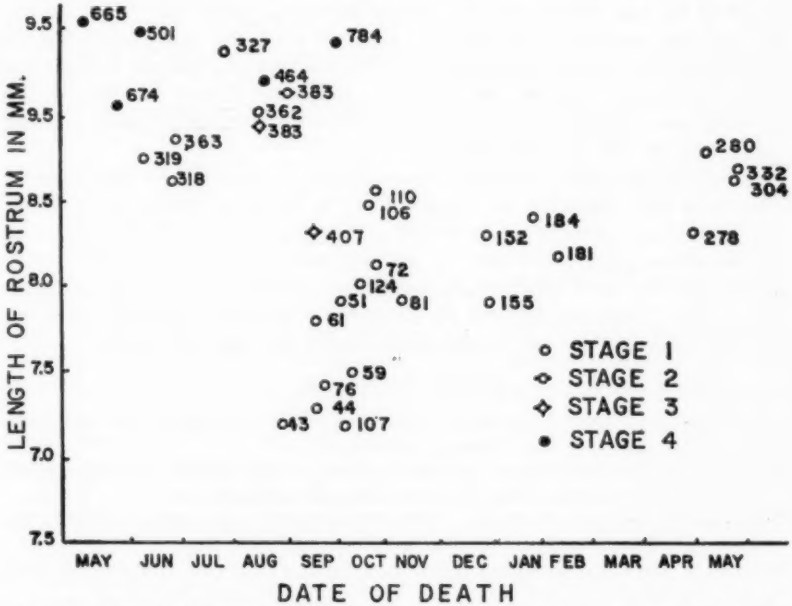

FIG. 7.—Length of rostrum, degree of extension of teeth, and age in days at death for phenacomys of known age.

rostral measurements of 71 phenacomys that were in captivity for more than 30 days, 50 whose skulls were taken from owl pellets at Ft. Churchill, 66 dead-trapped at Authier-Nord, and 207 dead-trapped at Ft. Churchill. Degree of extension of the teeth is also incorporated into the histogram. A vertical line has been drawn at the 8.2 mm length of rostrum, the point at which the roots of the teeth are first seen in the skulls from owl pellets, from Authier-Nord, and from phenacomys dead-trapped at Ft. Churchill. However, in those animals that have been kept in captivity for more than 30 days (including known-age mice) there are 19 individuals without teeth fully or almost fully extended located well beyond the 8.2-mm level for the wild population. This seems to result both from the molar teeth growing relatively slowly, and the rostrum relatively quickly, in laboratory-raised individuals. That teeth grow more slow slowly may be concluded from Fig. 2, which shows that in the laboratory-born phenacomys the teeth become fully extended at about 12 months of age, instead of the 8–10 month period required for the wild population. It appears that teeth grow more slowly in the laboratory mice, perhaps as a result of an inadequately balanced diet and/or a high proportion of softer food (rolled oats, carrots, etc.), the latter causing less wear on the teeth than does the wild vole's winter food (willow bark, etc.).

The rostrum grows relatively faster in the laboratory mice, as illustrated in Fig. 7. In Figs. 3 and 4, the age classes were clearly divided at the rostral length of 8.2 mm. But in Fig. 7, none of the upper group has a rostrum less than 8.6 mm, well above the 8.2 mm expected from the wild population. It seems likely that the laboratory mice, which were kept at a warmer temperature during the winter than the wild mice, expended less energy for growth. By growing more during the winter, the spring captive population has longer rostra than its wild counterparts.

As pointed out earlier, it appears that wild phenacomys in their third summer have teeth fully extended and badly worn. It therefore seems likely that a vole would have virtually no teeth left and would starve to death before the end of another year. But if our data are representative of the true situation in nature, very few mice would reach their fourth summer. Analysis of data from Figs. 3 and 4 indicates that the Ft. Churchill population consisted of 59 per cent juveniles, 36 per cent young adults, and 5 per cent old adults.

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EFFECTS OF PREGNANCY ON THE SPLEEN IN MICE

BY WAYNE H. DAVIS, JAMES R. BEER AND EDWIN F. COOK

ABSTRACT: Spleen size was analyzed in 2368 wild white-footed mice, *Peromyscus leucopus*, in Minnesota. Sex, season and type of death (chloroform or killer trap) did not affect spleen size. Females in late pregnancy showed an average increase of 50% in size of spleen. The cells in the nodules of spleens of pregnant mice were found to have large vesicular nuclei. It is suggested that this may be a reaction to an antigen produced by the embryos. Normal spleen size varied greatly (15–72 mg in animals of the same size), the S.D. being 13.6. Spleen weight versus body length is a straight line.

The present study was undertaken to determine the effects of non-pathological internal and environmental stresses on the size of the spleen in mice, to show the normal size range of the spleen, and to show what differences in relative size may appear with age. The work was supported by a grant (E 962) from the National Institute of Health. This is paper No. 4163, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul, Minnesota.

MATERIALS AND METHODS

White-footed mice, *Peromyscus leucopus*, were trapped at two-week intervals throughout the year in northern Anoka County, Minnesota. Snap traps were used from October to April. During the rest of the year mice were taken in live traps and chloroformed in the field. Weight, measurement, sex, reproductive condition, type of trap, molt, and date of capture were recorded for each individual. The spleen was removed and weighed to the nearest milligram. Over 2,000 animals were used. Those mice parasitized by botflies (*Cuterebra* sp.) were not included, for such infestation caused splenic enlargement. Helminths and ectoparasites were not considered as factors likely to affect spleen size significantly.

The samples were analyzed statistically for possible differences with respect to those factors most likely to affect spleen size in normal animals, i.e., sex, season, cause of death, and pregnancy. Body length was used as an index of growth and age because body weight showed too much individual and

seasonal variation due to differences in content of stomachs and amount of body fat. No pregnant animals were used in the determination of normal spleen size.

Three mice were brought into the laboratory alive and their spleens removed for histological examination. Two laboratory mice, *Mus musculus*, were also used in the histological studies.

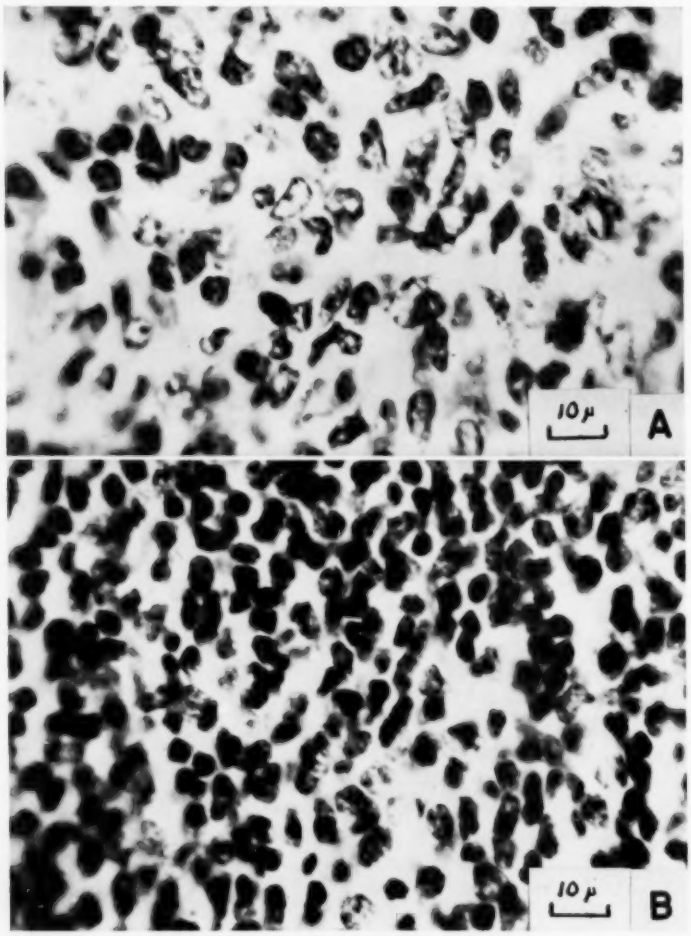

PLATE I

A, Section of nodule of spleen of laboratory mouse in late pregnancy, showing large vesicular nuclei; × 947. *B*, Section of germinal center of spleen of adult virgin laboratory mouse; × 947. Mercury formol saline fixative; Groat's hematoxylin. (*Photographs by R. L. Pipa.*)

RESULTS

Covariance analysis showed no difference in spleen size due to sex, season or cause of death. For samples of 23 of each sex taken in October, F = 1.23; for samples of 23 taken in each of the four seasons, F = 2.32; for samples of 23 taken in killer traps and 23 taken alive and chloroformed, F = 1.81.

Pregnancy, however, was found to be accompanied by a rather striking increase in size of the spleen. In late pregnancy (only those with at least three embryos 12 mm or more in crown-rump length were used) the average size of the spleen is about 52 per cent greater in a 95-mm mouse than in the average non-pregnant animal of the same size. The absolute increase is greater in larger mice, but the percentage increase remains about the same (Fig. 1). This curve is based upon analysis of 101 females in late pregnancy. There was no difference between first and subsequent pregnancies in the effect on

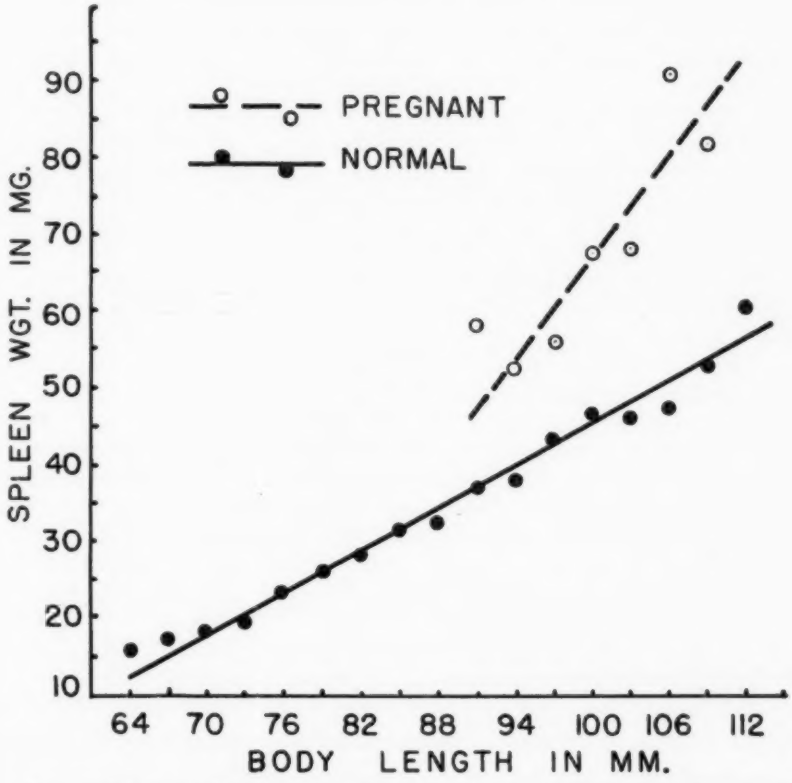

FIG. 1.—Spleen weights of pregnant (upper) and non-pregnant (lower) *Peromyscus leucopus*. Dots represent the average spleen weight for each size group.

spleen size (samples of 64 first pregnancies and 32 in second or later pregnancy, F = 2.33).

Microscopic examination showed some differences between the spleens of pregnant and non-pregnant mice. In pregnant mice the nuclei of the Malpighian corpuscles are enlarged and vesicular as compared with those in non-pregnant mice (Plate I), and the cells are more crowded (it was necessary to cut thinner sections to obtain photograph A). Megakaryocytes were common in the red pulp of the spleens of pregnant mice. A few were also present in a non-pregnant laboratory mouse.

The average size of the spleen of *Peromyscus leucopus* is shown on the lower curve on Fig. 1. The curve is based upon analysis of 2,267 non-pregnant, apparently healthy mice. The average size of the spleen of an 87-mm mouse is 33.1 mg. The size range of the "normal" spleen for 140 mice of 87 mm was 15–72 mg, and the sample standard deviation was 13.6.

The graphic relationship of spleen size to body length is a straight line, at least over most of the range included in this study. The very youngest animals (63–71 mm) seem to have a relatively larger spleen than older ones.

DISCUSSION

Recent work (Ortega and Mellors, 1957) has shown that the germinal centers of the spleen produce gamma globulin, and that those centers where the cells have a high nucleo-cytoplasmic ratio are far more active in producing gamma globulin than are those with small-nucleate cells. It seems likely, then, that the large-nucleate cells in the nodules of the spleens of pregnant mice may be active in antibody production.

Whether or not an increase in spleen size during pregnancy occurs in other mammals is not known. In the dog (Barcroft, 1930) and guinea pig (Sleeth and Van Liere, 1939) the spleen decreases in size in late pregnancy. In the dog this was shown to be due to the release of stored blood from the spleen, but possible changes in the spleen itself were not studied.

The function of the spleen as a blood storage organ varies greatly with different mammals. That it is not well developed in *P. leucopus* is suggested by the fact that there was no difference in spleen size between those taken in the killer traps and those which were chloroformed. In the dog, a striking shrinkage of the spleen occurs when chloroform or ether is administered (Barcroft, 1934).

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Dept. of Biology, Middlebury College, Middlebury, Vermont, and Dept. of Entomology and Economic Zoology, Univ. of Minnesota, St. Paul 1. *Received 28 July 1960.*

HEMATOLOGICAL VALUES IN DEER MICE IN RELATION TO BOTFLY INFECTION

By John A. Sealander

Abstract: An incidence of 31.8 per cent infection with botflies (*Cuterebra* sp.) was found in a population of deer mice (*Peromyscus leucopus noveboracensis*) trapped near the Queen's University Biological Station, Chaffey's Locks, Ontario, during July and August 1958. No infections were observed in mice trapped prior to 23 July. Infected mice had significantly lower hemoglobin concentrations and packed cell volumes than noninfected mice trapped during the same period. The possibility that reduced blood values resulting from myiasis might lower physiological resistance to environmental stressors sufficiently to contribute to population declines is considered.

While investigating hematological values in small mammals during the summer of 1958, a heavy incidence of botfly (*Cuterebra* sp.) infection was encountered in woodland deer mice, *Peromyscus leucopus noveboracensis*. From 23 July, when the first infection was observed, until 12 August, when trapping was discontinued, about one-third of the deer mice trapped were parasitized.

There has been considerable speculation that myiasis may cause increased mortality in a population by producing awkwardness and debility in infected individuals, thus making them more vulnerable to predators, and by lowering the physiological resistance of the host to environmental stressors. There has been little objective evidence presented in the literature to support the view that heavy incidences of dipteran infection in a population contribute to lowered physiological tolerance limits in a species. The present observations may, therefore, give some additional insight into this aspect of parasitism in mammalian populations.

METHODS

During July and August a total of 127 mice were trapped with Sherman live traps within a half-mile radius of the Queen's University Biological Station, Chaffey's Locks, Ontario. All of the mice were taken from overgrown fence rows surrounding pastures bordered by stands of mixed hardwoods interspersed with pines. Traps were set in the late afternoon and visited again in the early morning hours so that the trapped mice were not exposed to high daytime temperatures which could have caused some dehydration.

Soon after trapping, hematological measurements were made on tail blood from mice under light ether anesthesia. Hemoglobin concentration was measured with a Spencer hemoglobin meter; microhematocrits were determined by a modified Guest-Siler (1934) technique; and erythrocyte diameters were measured on dried smears with an ocular micrometer.

RESULTS

The incidence of infection (in 66 mice) for the period 23 July through 12 August was 31.8 per cent. In adult mice the incidence was 53.1 per cent,

and in subadults it was 11.8. The incidence was also higher in males (36.8 per cent) than in females (25.0). Nearly all of the cuterebrid larvae occurred singly and were usually either inguinal or scrotal in position. Only two of the parasitized mice harbored more than one larva. In one of them the larvae were inguinal and axillary in position, in the other inguinal and scrotal. About half of the larvae were almost ready to pupate, as indicated by size, brown chitinous integument and partial protrusion from the site of infection. In addition, four mice were trapped that showed fresh scar tissue in the scotal or inguinal regions. The blood values of all of these were essentially within the range of the average for unparasitized mice.

Blood values in parasitized and nonparasitized mice for the period 23 July to 12 August showed some very significant differences (Table 1). It is known that juvenile, pregnant or lactating animals may have lower blood values, but there were no pregnant or lactating females or juveniles among the parasitized mice trapped after 22 July so that the observed values were not affected by these factors. A few juveniles were trapped during the course of the study, but none were parasitized and measurements of blood values on them are not included in any of the comparisons. It is of interest to note that one female among the parasitized mice showed evidence of resorption of four embryos. Seven out of ten adult females in the group of unparasitized mice trapped before 23 July were pregnant, while only two out of thirteen adult females trapped after 22 July were pregnant. The blood values in these pregnant mice were not significantly lower than in the remainder of the unparasitized mice which included adult males and subadult males and females. There was no difference in erythrocyte diameter between parasitized and nonparasitized mice. Erythrocyte diameters ranged from 5.8 to 7.0 μ with means of 6.4 μ in all groups. Also there were no significant differences as between sexes or between subadults and adults.

DISCUSSION

Severe parasitism of the woodland deer mouse by botfly larvae has been observed by several investigators. Incidence appears highest during the months of August, September and October. Scott and Snead (1942) found incidences of about 30–35 per cent in September of 1939 and 1940 in Iowa, while in Indiana Test and Test (1943) found an incidence of 28.7 per cent in August. Dalmat (1943) observed an incidence of 38 per cent (25 of 68 mice) in Iowa during 1940 for the period from 15 September to 2 November. In the following year he found that 54 per cent of the mice trapped in the same area were parasitized.

The effect of botfly infections on small mammal populations is difficult to establish and has been largely a matter of conjecture. Scott and Snead (1942) and Dalmat (1943), as well as the writer, have observed that infected mice show awkwardness in locomotion, particularly if the larvae are located in the inguinal or scrotal regions. It is conceivable that impairment of locomotor ability might make infected mice more vulnerable to predation. There also

TABLE 1.—*Blood values in deer mice infected with botfly larvae compared with those in noninfected deer mice (Mean ± standard error, ranges in parentheses)*

Variable	Infected mice, 23 July to 12 August	NONINFECTED MICE		t value	P
		1 July to 22 July	23 July to 12 August		
Number of animals	21	61	45		
Hemoglobin concentration, gm/100 ml	12.2 ± 0.2 (10.3–13.5)	14.9 ± 0.1 (11.8–16.2)	14.9 ± 0.1 (13.3–15.9)	11.74	< .001
Hematocrit, %	39.8 ± 0.8 (32.3–44.9)	46.3 ± 0.4 (37.9–52.2)	46.3 ± 0.3 (40.6–51.6)	9.28	< .001
Mean corpuscular hemoglobin concentration, %	30.5 ± 0.3 (29.4–33.9)	32.2 ± 0.2 (29.1–35.4)	32.3 ± 0.2 (29.5–35.1)	5.14	< .001

has been speculation (Test and Test, 1943) that the larvae constitute a drain on the vitality of the host because of their large size. However, infected mice do not have an emaciated appearance and show few outward symptoms of physiological abnormalities such as anemia. It is possible, nevertheless, that decreased physiological vigor might make the parasitized animals more susceptible to environmental stressors and predators. In this connection, it has been noted (Scott and Snead, 1942; Wilson, 1945) that increased incidences of *Cuterebra* infections in deer mice are usually coincident with lower population densities and downward trends in population (see also Elton, 1931 and Elton *et al.*, 1931). Emasculation of male mice by the parasite has been noted frequently; this may also contribute to a lowered reproductive potential.

In the present study, it was found that both the hemoglobin concentrations and the packed cell volumes of infected mice were significantly lower than in uninfected mice. There was relatively little overlap in values from infected and noninfected mice, especially in hemoglobin concentrations. In all of the noninfected mice (a total of 106) there were only six instances in which the hemoglobin concentrations of noninfected mice overlapped those of infected mice. Five of the noninfected individuals in which hemoglobin concentrations overlapped had values in the upper end of the range for infected mice and only one was in the lower end of the range. The differences were not as clear-cut for packed cell volumes, but were still well marked. In 32 instances of overlapping values between infected and noninfected mice, only two values from noninfected mice were in the lower end of the range of values for infected mice. On the basis of these observations it seems evident that the fly larvae produced an anemic condition in the infected mice. No *Bartonella* examinations were made, but it seems improbable that a concurrent infection of this type could have caused the anemia.

It is possible that a generally anemic condition, whatever the cause, might lower resistance to various kinds of stress. If dipteran parasitosis should occur at a time of high population density, when members of the population are subjected to profound physiological alterations resulting from crowding stress, which tend to reduce their survival potential (Christian, 1957), then at least

part of any subsequent population decline might be triggered by the infection. The smaller number of pregnant mice taken after 22 July, and the additional finding of embryo resorption in one female, suggests an incompatibility between botfly infection and maintenance of pregnancy. It might also result from the fewer mating encounters, due to parasitic disablement of a portion of the males in the population. Slight anemias are normally associated with pregnancy and lactation, and it may be possible that the presence of the larvae aggravates such anemias to the extent that termination of pregnancy or loss of a suckling litter results. A lowering of physiological resistance in a segment of the population could thus contribute indirectly to a population decline. That botfly infections may contribute directly to mortality in a population is indicated by the observation of Dalmat (1943) that about 20 per cent of infected mice that were caged died at the time the larvae started to emerge.

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Dept. of Zoology, Univ. of Arkansas, Fayetteville. *Received 23 February 1960.*

THE MEXICAN BIG-EARED BAT IN ARIZONA

By Larry R. Commissaris

Abstract: Observations made during the summer of 1958 have added to the knowledge of the habits and ecology of *Plecotus phyllotis*, 29 specimens of which were taken during the summer. The majority were taken in association with Mexican pine-oak woodland, although a few were taken from other habitats that were either similar to or in geographical proximity to pine-oak woodland. Those individuals taken in mist nets were active well after dark and during fair weather. Observations on their flight under natural conditions indicate that they are swift, agile flyers. These bats made many audible sounds during flight in the wild.

The Mexican big-eared bat, *Plecotus* (*Idionycteris*) *phyllotis*, is one of the least known of the bats of the southwestern United States. The first specimen from the United States, taken from the Chiricahua Mountains of southeastern Arizona, represented the third specimen in existence (Cockrum, 1956). Subsequent field work in the same area and other parts of the state has yielded 32 additional specimens. Most of these bats were collected with the aid of mist nets at waterholes. This paper reports observations on the ecology and habits of these specimens.

The specimens collected during this study were taken at the following localities within Cochise County: South Fork of Cave Creek, Chiricahua Mountains, 5400 ft. (14); Southwestern Research Station of the American Museum of Natural History, Cave Creek canyon, 5400 ft. (4); Waterhole 1 mile northwest of Portal, 4900 ft. (3); and Portal, 4750 ft. (1). In Graham County these bats were taken at Oak Grove Canyon, Galiuro Mountains, 3550 ft. (10).

Four specimens were deposited at the American Museum of Natural History or its field station, and the rest in the mammal collection of the Department of Zoology, University of Arizona.

Habitat.—This species seems to prefer Mexican pine-oak woodland of the type discussed by Marshall (1957). In Cave Creek canyon, the dominant vegetation consists of Apache pine (*Pinus latifolia*), Chihuahua pine (*P. chihuahuana*), Arizona oak (*Quercus arizonica*), Emory oak (*Q. emoryi*), and a strong infusion of riparian elements including Arizona sycamore (*Platanus wrightii*), cottonwood (*Populus fremontii*), chokecherry (*Prunus virens*), Arizona walnut (*Juglans major*), and several species of willow (*Salix* sp.). From this community, there is a transition into the oak-juniper assocation of the adjacent hillsides, which includes the same species of oak and *Juniperus deppeana*.

In the South Fork of Cave Creek, where the majority of the big-eared bats have been collected, the habitat is similar to Cave Creek canyon. The slopes are dominated by oak-agave growth, however, while the canyon floor supports the typical pine-oak species, with the same riparian elements.

At Portal, which lies within the riparian association of Cave Creek, the pines are no longer present, while sycamore and cottonwood play a more

prominent role. A short distance from Portal, the taller trees are no longer present and mesquite (*Prosopis juliflora*) and desert willow (*Chilopsis linearis*) invade the streamside association. Because *P. phyllotis* seems to be closely associated with woodland, and has never been collected far from it, the lower limits of woodland may represent the limits of suitable habitat for this species.

The waterhole one mile northwest of Portal represents an exception to the woodland type of habitat. Here the vegetation consists of mesquite, whitethorn (*Acacia constricta*) and several species of agave. The appearance of the area is much different than that of the other localities because a shrubby growth predominates. There is some question whether *P. phyllotis* actually uses this habitat extensively in its nocturnal feeding, or whether it flies to this area specifically to drink, then returns to the riparian habitat one mile distant. Other bats, including the big brown bat and the western pipistrel have been observed flying to this tank from the riparian area, drinking, and then returning to the streamside association, suggesting that the Mexican big-eared bat does likewise.

At Oak Grove canyon in the Galiuro Mountains the vegetation in the canyon bottom is very similar to that described for riparian situations in the Chiricahua Mountains. The dominant plants are walnut, sycamore, and New Mexico alder (*Alnus oblongifolia*), while the uplands adjoining the canyon are largely agave-grassland.

Distribution.—The distribution of *P. phyllotis* in Arizona, as now known, is limited to the Chiricahua and Galiuro mountains. However, in spite of our limited knowledge, it seems possible that *P. phyllotis* has a much wider range. Figure 1 shows the localities where this species has been collected and indicates the probable range. This postulated range is based on Nichol's (1952) map of the natural vegetation of Arizona and includes areas with habitat similar to that in which this bat has been collected. Areas of pine-oak woodland are found as far west as the Baboquivari Mountains. Habitat of almost the same nature is found in the Galiuro and Pinaleno mountains. Yellow pine forest and oak woodland, with transition zones similar to the known habitat of *P. phyllotis*, are found not only in the mountains of the southeastern part of the state, but also as far north as the San Francisco Peaks area near Flagstaff. Thus, this species may possibly range as far north as Flagstaff.

Diurnal roosts.—The specimens collected at Oak Grove canyon are the only ones taken in a roost. This roost was in a large, open-fronted cave almost 800 feet wide and 100 feet deep, formed by water undercutting the canyon wall at a sharp bend. Part of the roof has fallen in, leaving a tremendous pile of boulders and rubble to a depth of about 100 feet on the floor of the cave. Between and among these boulders are interconnected spaces and in these passages *Myotis thysanodes, Plectotus townsendi,* and *P. phyllotis* were found. On 23 August 1958, there were approximately 30 *P. phyllotis* present. Of these, 14 were captured (four of them banded and released by Alfred

Gardner and E. Lendell Cockrum). The rest escaped through the labyrinth of passages. All the specimens collected were females and young of the year, indicating that this roost was being used as a maternity colony. Subsequent trips to the same area (8 February, 9 May and 29 August 1959) have failed to reveal this species.

Circumstances of capture.—Information on the time of capture and prevailing weather conditions was obtained for 15 specimens from the Chiricahua Mountains. These specimens were taken between 3 June and 11 July 1958.

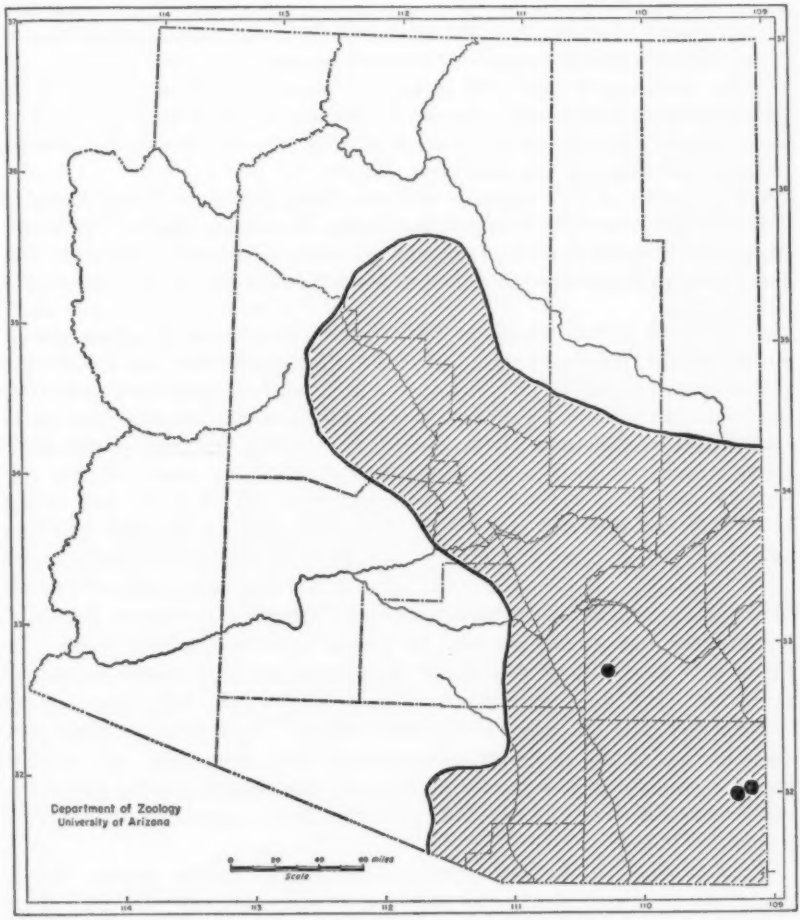

FIG. 1.—Map showing the localities of capture and probable distribution of *Plecotus phyllotis* in Arizona. See text for further explanation.

In general, these bats were late in flying. Only one was taken while there was still any trace of light in the west. This one was taken at 8:30 PM on 25 June and represented the earliest capture, while the latest was recorded at 11:40 PM on 3 June. The mean time of capture was 9:42 PM.

Weather conditions were clear and calm during the evenings on which 9 of the 15 were taken. Four other individuals were taken under a scattered cloud cover composed of altocumulus clouds, while two were captured on an evening with a slight cirrus overcast. At no time was there a strong wind or adverse weather, although netting activities were carried on in the same area under such conditions. The air temperature at the times of capture ranged from 61 to 82° F., with a mean of 72°, while the humidity had a mean value of 34 with extremes of 26 to 53 per cent.

These data suggest that in the summer *P. phyllotis* is active at water holes well after dark, during calm weather of moderate to warm temperatures, and with relatively low humidity. Because netting was usually stopped around midnight, no morning activities were recorded.

Other species of bats captured with the Mexican big-eared bats included *Choeronycteris mexicana, Tadarida brasiliensis, T. molossa, Myotis californicus, M. evotis, M. subulatus, M. thysanodes, M. volans, Pipistrellus hesperus, Eptesicus fuscus, Lasiurus cinereus, L. borealis, Plecotus townsendi,* and *Antrozous pallidus.*

Habits.—On six occasions big-eared bats were observed as they flew around the area before becoming entangled in the net. On 24 June 1958 a male was observed flying swiftly down the canyon at approximately 15 feet above the creek bottom. It turned sharply and swooped downward, striking the net at high speed. On the next night, at the same netting station in South Fork canyon, another individual was seen to follow almost the same path into the net. In this case, however, the individual was one of three bats flying in a group; the other two successfully avoided the net. At the stock tank one mile northwest of Portal, the characteristically rapid flight of *P. phyllotis* was again observed. On the night of 2 July at 9:30 the moon was sufficiently bright to allow good observations of two bats flying rapidly around the water hole. These bats circled the area for several minutes, cheeping rapidly all the while, before diving down toward the water where they became enmeshed in the net. Both were male Mexican big-eared bats. The following night at 9:14 another male was taken in the same manner. Their agility in flight was also observed at the maternity colony, where they flew easily and quickly through the maze of passages within the rocks, and among captive specimens which were observed to hover and rise vertically to a height of 12 inches in a large bell jar.

Plecotus phyllotis has been heard making several audible sounds. When these bats were seen flying over the desert tank northwest of Portal, they emitted a very rapid cheeping, verging almost to a rapid clicking (somewhat like *Eptesicus* but more rapid and without the intensity). Two males caught

in the net at different times both made a low, barely audible cheeping very much like that of *P. townsendi*, but most individuals taken were silent.

Protecting the ears by coiling them in the "ram's horn" pattern characteristic of *P. townsendi* is also practiced by *P. phyllotis*. When entangled in the net, both species often coil the ears, apparently in an attempt to prevent damage from the net. At other times, however, the Mexican big-eared bat keeps the ears folded back on the shoulders. This posture was observed in captive individuals at rest during the day and also in individuals kept in cages with other bats. In the latter situation, the ears were probably kept back as protection from damage by other bats.

In captivity, these bats were docile and seemed more interested in protecting their delicate ears than in being pugnacious. They made little effort to bite while being removed from the net or handled. One male, taken from a window screen at the Portal school, proved to be an exception. He attempted to bite when handled and was extremely active in his cage. This individual refused to take food or water and died several hours after capture. The odd circumstances of capture and his extreme activity suggest that he may have been diseased. The only other antagonism shown by these bats was when two males were placed together in the same cage. They appeared irritated when they made contact with each other, suggesting that, at least during the summer, the males are somewhat solitary.

Acknowledgments.—I am indebted to Alfred Gardner and E. Lendell Cockrum for the use of their data on the Galiuro Mountain colony, to Luther Little for critically reading the manuscript, and to the personnel of the Southwestern Research Station of the American Museum of Natural History for their help during the summer of 1958. To all these people I extend my grateful thanks.

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NOTES ON FOOD HABITS OF BATS

By Anthony Ross

Abstract: Observations were made on the diet of five insectivorous bats (*Lasiurus borealis, Euderma maculata, Eumops perotis, Tadarida brasiliensis* and *Antrozous pallidus*). Reported are percentages of insect remains for each species, obtained from guano, stomach contents or fragments found under the night roost. Discussed are methods used in obtaining insect samples and limits on the level of taxonomic determinations, caused primarily by thorough chewing by the bats. Foods of *A. pallidus* from four localities in southern Arizona included representatives of 6 orders, 43 genera and 22 identifiable species of insects, several of them flightless forms.

In the course of this study, materials pertaining to the following five species of insectivorous bats were examined: *Lasiurus borealis* (guano), *Euderma maculata* (guano), *Eumops perotis* (guano and stomach contents), *Tadarida brasiliensis* (stomach contents), and *Antrozous pallidus* (stomach contents, guano, and insect remains dropped below night roosts).

The examination of bat guano was facilitated by the immersion of the pellets in a solution of Photo-flo and water to soften the pellets. Those bats that drop remains of insect parts at their night roost usually leave head capsules, thoracic segments, legs and wings of the hard-bodied insects; wings and legs of the soft-bodied insects; and only the wings of lepidopterous insects.

The taxonomic level to which insect remains from stomach and pellets of a bat can be identified depends upon the type of insect eaten and upon how thoroughly the bat chews it. Bats feeding on small moths and chewing them completely leave merely minute fragments which are distinguishable to ordinal level only. In those bats that do not chew the insects so thoroughly, it is possible to obtain family level determinations in most instances. With the pallid bat, *Antrozous pallidus*, species level determination was possible for the insect remains in most cases, because of this bat's habit of feeding on larger insects, chiefly the abdomens, letting the harder parts drop to the ground under their night roost.

Listed beyond are data on the foods of the five species of bats. Under *Insect fragments*, the figures are percentages which refer to the number of specimens in each group of insects in relation to the total.

Eumops perotis (Schinz)

Locality: Cave, Secret Pass, 15 mi. W, 5 mi. S Kingman, Mohave Co., Arizona, 26 September 1959. Collectors, Wm. Musgrove and E. L. Cockrum. Guano and stomachs.

Four stomachs and 43 pellets were examined. In most cases the condition of the insect remains permitted only family-level determinations except for one hard-bodied beetle.

Insect fragments.—Odonata: Aeshnoidea, 1. Orthoptera: Acrididae, 10. Hemiptera: Miridae, 10. Coleoptera: Scarabaeidae, *Cremastocheilus* sp., 1,

Tenebrionidae, 5, Curculionidae, 5. LEPIDOPTERA: moths, 10. HYMENOPTERA: Halictidae, 36, Formicidae, 12, Megachilidae, 5, Anthophoridae, 5.

The food habits of this bat apparently are unusual in that 58 per cent of the diet consists of night-flying hymenopterous insects. No hymenopterous insects were noted in the diet of the other four insectivorous bats. This large bat is also unusual in regard to the fact that it feeds on rather small insects (most of them approximately 8 mm in length). The habits of the insects on which this bat had been feeding (low-flying, weak-flying forms) indicates that *E. perotis* normally feeds from near ground level (3 to 4 feet above the surface) to treetop level.

Euderma maculata (J. A. Allen)

Locality: Ghost Ranch, Rio Arriba Co., New Mexico, 17 September 1958. Collector, Denny Constantine. Guano only.

Only 18 pellets were examined from this rare bat, and due to the condition of the insect remains, determinations could be made only to ordinal level.

Insect fragments.—LEPIDOPTERA: moths, 100.

The remains of 21 adult moths were found in the 18 pellets. These moths were approximately 8 to 12 mm in length.

Lasiurus borealis (Müller)

Locality: Cemetery, Capay, Yolo Co., California, 10 August 1954. Collector, Denny Constantine. Quano only.

Ten large (18 mm) pellets were examined, and again only ordinal level determinations could be made in the majority of the cases.

Insect fragments.—ORTHOPTERA: Acrididae, 10, undetermined orthopterans, 29. COLEOPTERA: Ptilidactylidae, 1. LEPIDOPTERA: moths, 60.

This bat appears to feed on small moths (mostly 10 to 16 mm in length), but takes other insects occasionally (some as large as 30 mm in length).

Tadarida brasiliensis (I. Geoffroy St.-Hilaire)

Locality: Waterhole, mouth of Madera Canyon, Santa Rita Mts., Pima Co., Arizona, 10 April 1959. Collectors, A. Gardner and A. Ross. Stomachs only.

Seven stomachs were examined, and only ordinal level determination was possible for the majority of the insect fragments present. In the lepidopterous insects I did encounter one complete head capsule of a moth of the family Gelechiidae. I feel that most of the moth remains belong to this family or closely related families, with the exception of one moth that was approximately 18 mm in length belonging to an undetermined family.

Insect fragments.—HOMOPTERA: bugs, 1. DIPTERA: Dolichopodidae, 4. LEPIDOPTERA: moths, 95.

Most of the insects were approximately 5 to 9 mm in length. Storer (1926) reported finding Coleoptera and other orders in his examination of guano from these bats, besides large numbers of moths. Apparently these bats feed on moths and occasionally take other prey captured with no selectivity.

TABLE 1.—*Percentage of different insects found at each locality by species*

Insect prey	Locality No. 1	2	3	4
ORTHOPTERA:				
Stenopelmatinae				
Stenopelmatus sp. *	4	1	2.4	0.6
Phaneropterinae				
Microcentrum californicum	4		10.4	
Decticinae				
Capnobotes fuliginosus		4	1.6	2.4
Oedipodinae				
Trimerotropis sp.		1	1.6	
Arphia sp.				1.8
Xanthippus sp.				1.2
Cyrtacanthacrinae				
Schistocerca sp.			4.8	
Schistocerca vaga				23.4
Romaleinae				
Taeniopoda eques				0.6
Mantidae				
Stagmomantis sp.				0.6
HOMOPTERA:				
Cicadidae				
Diceroprocta apache			1.6	0.6
HEMIPTERA:				
Belostomatidae				
Abedus sp.			4.0	
Coreidae				
Thasus acutangularis			1.6	50.8
Acanthocephala granulosa			3.2	
NEUROPTERA:				
Myrmeleontidae				
Hesperoleon sp.			0.8	
COLEOPTERA:				
Carabidae				
Pasimachus californicus †	4			
Calosoma sp.		1	20.8	
Calosoma scrutator			0.8	
Tenebrionidae				
Euschides convexus †	4		4.0	9.6
Edrotes ventricosus †			0.8	
Silphidae				
Nicrophorus sp.		1		
Scarabaeidae				
Orizabus clunalis	20		5.6	
Plusiotis gloriosa	20	8	2.4	
Polyphylla spp.		20	8.0	
Trox sp.			0.8	
Cotinus sp.				0.6
Cerambycidae				
Prionus californicus	4		8.8	
Archodontes sp.		9	4.8	

TABLE 1, *continued*

Insect prey	Locality No. 1	2	3	4
Cerambycidae, *cont'd.*				
Archodontes aridus	4			
Prionus sp.	15	10		
Derobrachus sp.	4	10		
Nothopleurus sp.		9	4.0	
Oncideres rhodosticta				7.8
LEPIDOPTERA:				
Sphingidae				
Chlaenogramma jasminearum	4			
Celerio lineata	4	1	3.2	
Protoparce sp.			2.4	
Lasiocampidae				
Dicogaster sp.		14		
Dicogaster coronada	9	1		
Cloveria arizonensis		3		
Saturniidae				
Telea sp.			0.8	
Telea polyphemus		1		
Noctuidae				
Catocala sp.		6		
Arctiidae				
Apantesis proxima			0.8	

* indicates wingless forms.
† indicates flightless forms.

An interesting note is that I have twice found the head capsules of ants (reproductive flying forms) embedded in the angles of bats' mouths, once on a free-tailed bat in Mexico, and again on a leaf-nosed bat, *Macrotus californicus*, in Arizona. These particular head capsules had their mandibles well embedded in the bat's tissue and apparently had been attached for a long period, as both capsules were dry and the bat's tissue had grown around the ant's mandibles. Both of these ants were of the genus *Camponotus*, that on the leaf-nosed bat being *C. vafer*. Wilson (1958) also noted this condition in *Eptesicus fuscus*.

Antrozous pallidus (Le Conte)

In this study discarded insect parts, guano and stomach contents were examined from four different plant-life zones to determine if there was any evidence of food selection by these bats in a given area. The four zones were as follows: Locality No. 1, Mine, 20.8 road miles south of Oracle, on Control Road, Pima Co., Arizona, 4 September 1959, night roost; collector, G. VR. Bradshaw. This mine is in the Upper Sonoran zone. Locality No. 2, Mine tunnel, 1 mile north of Paradise, Cochise Co., Arizona, summer accumulation of insect parts, night roost, 1958; collector, E. L. Cockrum. The determinations of the insect fragments from this locality were made 6 December 1958 by F. G. Werner, Department of Entomology, University of Arizona. This tunnel is in

a canyon with a pinyon-juniper association. Locality No. 3, Second Mine, second stream crossing, 5.4 miles east of Oracle Junction, 6.6 road miles south of Highway 77 (Burney Mine Road), Pinal Co., 11 October 1959; collector, G. VR. Bradshaw. Mountainous grassland with oak, cottonwood, sycamore. Locality No. 4, D. G. Hibbs Ranch, ca. 24 miles north of the Mexican border, east base of Baboquivari Mountains, 3800 feet, Pinal Co., Arizona, 16 October 1959; collector, E. L. Cockrum. Mesquite shrubs are the dominant plants in this area.

Apparently these bats will feed on all of the larger night-flying insects (20 to 70 mm in body length, wingspans up to 160 mm) and flightless insects (20 to 40 mm in length) that are available in these zones, with no indication of food selection. These bats feed on nocturnal flightless insects (*Stenopelmatus, Euschides*) in such large numbers that it would indicate that these bats alight on the ground and actively search for these insects. Orr (1954) also noted that the pallid bat feeds on *Stenopelmatus* in California and Arizona.

Insect fragments identified from the four localities are summarized in Table 1. In addition, remains of one scorpion (*Hadrurus* sp.) of the family Vejovidae were identified from Locality No. 4.

It is interesting that pallid bats at Locality No. 3 were feeding on predaceous water bugs (*Abedus*), but there is a stream in this area, and these bugs leave the water to mate. At this time the bugs fly or crawl over the ground looking for mates. These are large bugs, approximately 30 mm or larger in length.

The scorpion was the only one encountered in this study and, as scorpions are fairly abundant in Arizona, it appears that scorpions are not a normal part of the pallid bat's diet, even though there are other reports of this feeding habit (Orr, 1954). Perhaps these scorpions are captured while the pallid bats are searching the ground for Jerusalem crickets (*Stenopelmatus*) and flightless darkling beetles that they normally catch.

At Locality No. 4 one would expect the high per cent (50.8) of the very large (35 mm) bug (*Thasus*), as it is one of the primary insects in this association. However, it is a very foul-smelling insect.

The stomachs and guano of pallid bats from these areas indicate that these bats do not feed on the smaller insects, since all of the insect fragments found were greater than 17 mm in length. Only the cerambycid *Oncideres* (Locality No. 4) was in the 17-mm range, while the other insects were much larger. This study of the pallid bat's food habits also indicates that these bats do not feed on immature (larval or flightless nymphal) forms which are to be found on vegetation, and their perference for flightless forms is limited to those large forms that are found on the ground.

Conclusions.—From this study it is apparent that *Euderma maculata, Tadarida brasiliensis* and *Lasiurus borealis* feed primarily on small moths, occasionally taking other small insects that they may encounter, except that *Lasiurus borealis* will also feed on larger insects as well. *Eumops perotis* feeds principally on small hymenopterous insects, which apparently is an unusual

diet among bats, and it too feeds on other small insects. This bat probably feeds from near ground level to treetop heights. *Antrozous pallidus* is a very generalized feeder on the larger insects that occur in its habitat, and it apparently actively seeks out ground-inhabiting flightless insects (chief among them, the Jerusalem cricket).

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CUVIER BEAKED WHALES STRANDED IN THE ALEUTIAN ISLANDS

BY KARL W. KENYON

ABSTRACT: Two Cuvier beaked whales, *Ziphius cavirostris*, a female (USNM No. 288019) and male (USNM No. 288020), were found on beaches of Amchitka Island, Alaska, in March and April 1960. The female was fresh, the male considerably decomposed. This is a widely distributed but uncommon species. The skulls of both animals were preserved. Rifle fire appeared to have caused death. The female weighed 2952.5 kg and measured 658 cm in standard length; the male was 543.5 cm long. The sectioned teeth of the female revealed 24 to 28 growth layers, of the male 13 layers. Presumably each layer represents one year of life. Examination of the ovaries revealed five small follicles and one (possibly two) corpora albicantia. The stomach of the female contained the remains of 1,304 squids and the immature stage of a species of *Anisakis*, a parasitic nematode. Little is yet known of the biology of this whale.

Scattered reports indicate that the Cuvier beaked whale, *Ziphius cavirostris*, is world-wide in distribution but nowhere abundant. In the Aleutians, a stranded male was recorded from Samalga Island by Scheffer (1949). Little is known of the biology of this whale.

On 26 March 1959, a freshly killed adult female Cuvier beaked whale washed ashore in Constantine Harbor (51°24′N, 179°19′E) on the north side of Amchitka Island, Alaska. Because it lay among rocks, we towed the carcass at high tide to an abandoned pier, beached it, and at low tide measured, dissected, and weighed it in sections (Tables 1 and 2). The skull (USNM No. 288019), ovaries, and stomach contents were preserved. Death had been caused by a bullet which entered the left side of the head, breaking the supraorbital ridge and piercing the lower jaw and throat. Nasal passages

were choked with clotted blood. Innokenty Golodoff and John Nevzoroff found the whale and Robert D. Jones assisted in weighing it.

On 23 April, Jones discovered a second Cuvier beaked whale at the head of Kirilof Bay, approximately 4 airline miles from site of the first find. It was a male, badly decomposed, shot through the throat. Presumably both whales had been killed at about the same time. Measurements obtained are recorded in Table 1. The skull is USNM No. 288020.

Reproduction.—The ovaries taken from USNM No. 288019 weighed 45.5 and 56.7 grams. The smaller contained four follicles ranging from 4 to 8 mm in diameter, and possibly one corpus albicans. The larger contained one corpus albicans 30 × 35 mm, and one small follicle. No corpus luteum was present.

Dentition and age.—All teeth were non-functional, being completely imbedded in the gums. The dentition of the female consisted of two pairs of teeth near the tip of the lower mandible (one pair is apparently usual). Smaller unpaired teeth were scattered at irregular intervals along the jaws (Plate I). The dentition of the male consisted of only one pair of teeth at the tip of the lower jaw.

One of the large teeth from each specimen was ground in longitudinal section and polished, after a technique developed by Japanese and American biologists for aging fur seals (Scheffer, 1950) and whales (Nishiwaki and Yagi, 1954).

TABLE 1.—*Measurements of two Ziphius cavirostris*

Measurements*	USNM 288019 ♀, cm†	USNM 288020 ♂, cm†
Snout to tail notch	657.9	543.5
Snout to gape	34.0	28.5
Snout to eye	73.0	–
Snout to blowhole	66.0	–
Snout to insertion of flipper	132.1	131.0
Snout to insertion of dorsal fin	425.4	350.0
Snout to anterior end of genital opening	411.5	330.0
Snout to anus	444.5	371.5
Tip of lower jaw to throat groove	29.8	–
Length of throat grooves	30.5	–
Length of flipper (anterior edge)	70.0	52.0
Length of flipper (posterior edge)	56.0	42.0
Width of flipper (greatest)	17.7	–
Length of genital opening	35.0	–‡
Length of mammary slit	12.0	–
Length of base of fin	40.0	35.0
Height of fin	25.0	21.0
Flukes, tip to tip	175.0	133.5
Flukes, width (greatest)	51.0	–
Girth, mid-belly (greatest)	362.0	–

* All measurements straight line, parallel to long axis.
† Length in feet: female, 21.7; male, 17.8.
‡ Length of extruded penis: 13.0 cm.

Seasonal interruptions in deposition of dentine were revealed. Heavy deposits of dentine in the region of new growth prevented exact counting of the layers. In the female there were not less than 24 nor more than 28 layers, and the pulp cavities were virtually closed. Twelve rings were visible externally on the teeth of the male (Plate I), while the polished longitudinal surface revealed about 13 growth layers; the pulp canal was open. We do not know how many layers are deposited annually in *Ziphius*. Sergeant (1959) demonstrated that *Tursiops* shows a single layer of dentinal growth annually, similar to the condition found in pinnipeds, but Nishiwaki *et al.* (1958), believe that sperm whales (*Physeter catodon*) may deposit two layers annually.

As stated previously, the ovaries of the female contained one corpus albicans (possibly two). One *Tursiops* born in captivity first became pregnant at the age of 6 years and other captives were bred only in alternate years (Tavolga and Essapian, 1957). Nishiwaki *et al.* (1958) believe that the female sperm whale attains sexual maturity at the age of 4 years. It appears logical to us to assume that one dentinal layer is deposited annually in *Ziphius* and that

PLATE I

LEFT: Teeth from the lower jaw of an adult female Cuvier beaked whale, USNM No. 288019. Teeth from the left jaw are above. The small vestigial teeth may not be in correct anterior-posterior order. The two largest teeth were farthest anterior.

RIGHT: Tooth from right lower jaw of a male Cuvier beaked whale, USNM No. 288020. Rings, similar to the annular rings on pinniped teeth, are visible.

corpora albicantia do not persist for more than 3 or 4 years. Alternatively, it could be assumed that two layers are deposited annually, that the age of the female was 12 to 14 years, the male 6 to 7 years and that sexual maturity in the female occurs somewhat later than in *Tursiops* and *Physeter*.

The length measurements of both specimens fall within the ranges given by Omura *et al.* (1955) for sexually mature Cuvier beaked whales.

Clifford Fiscus ground and polished the teeth and, with Victor B. Scheffer, assisted in obtaining age readings from them.

Stomach and food habits.—The stomachs of ziphioid whales are divided into as many as 9 to 14 compartments according to Beddard (1900). The stomach of specimen USNM No. 288019 had five compartments connected by openings 2.5 to 5.0 cm in diameter. The stomach and its contents are best described in the accompanying field sketch (Fig. 1).

A—Large anterior compartment, walls thick and rugose. Contents: 6,100 ml pinkish liquid; 100 ml of beaks from 12 squids (*Gonatus* and at least one other unidentified species); eye lenses from 106 squids; fragments of squid stomachs, which in turn contained fragments of 2 reddish shrimps (species?).

B, C, D—Small compartments, smooth-walled.

PLATE II

Irregular white markings were scattered over much of the body of an adult female Cuvier beaked whale, USNM No. 288019. The area shown is midbody, ventral quarter.

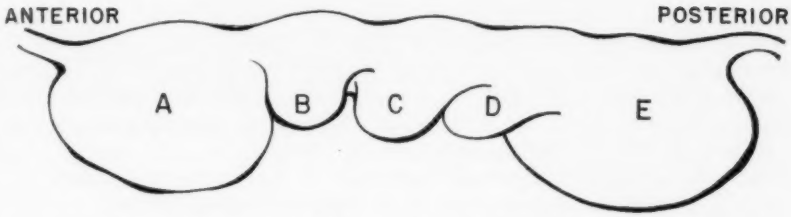

FIG. 1.—Sketch of stomach of adult female Cuvier beaked whale, USNM No. 288019.

E—Large pyloric compartment, walls smooth. This, together with the preceding three chambers, contained 10,300 ml of thick soupy brown liquid in which floated droplets of red oil. Mostly in compartment E: 1,700 ml hard parts consisting of beaks from 1,292 squids; eye lenses from 1,000+ squids and a tangle of squid pens and spermatophores. Five pens measured 45 to 53 cm in length, indicating that a number of the squids eaten may have measured nearly a meter in total length.

In summary, the stomach of the female contained 16,400 ml liquid plus 1,800 ml hard parts which consisted of the remains of 1,304 squids.

Parasites.—The anterior compartment contained approximately 60 roundworms and the pyloric compartment about the same. None was attached to the stomach wall. Leo Margolis has identified these as the "larval and immature stages of a species of *Anisakis*. Because of the lack of sexually mature individuals, I cannot take the identification beyond the generic level" (*in litt.*, 1959).

TABLE 2.—*Weights of body parts, female Ziphius cavirostris*[*]

	Kg.
Meat, blubber and bone (including head)	2717.0
Heart	15.4
Right lung	20.4
Left lung	19.1
Liver	25.9
Right kidney	8.7
Left kidney	7.7
Reproductive tract[†]	20.7
Intestines and contents	41.3
Stomach and contents[‡]	36.3
Spleen	0.085
Aorta, bronchi and connective tissue	31.6
Blood[§]	8.1
Total	6,509 lb. or 2952.5

[*] Chatillon spring scales of 500 pound, 50 pound and 15 pound capacities were used.
[†] With mesentery.
[‡] Weight of stomach contents: 18.6 kg.
[§] Most of the body fluids were lost. No estimate is included for the fluids not weighed.

Color.—Adult female only: body color black except for white markings 5 to 8 cm long and 2 to 5 cm wide (Plate II). While certain white marks on whales have been traced to attacks by lampreys (Pike, 1951), the marks on our specimen were irregular and may have originated in some other way. Jaws and snout whitish and grayish white on top of head; tip and posterior margin of dorsal fin grayish white.

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BREEDING HABITS OF BOBCATS IN UTAH

By Jay S. Gashwiler, W. Leslie Robinette and Owen W. Morris

Abstract: The sex ratio of trapped bobcats revealed a preponderance of males. Breeding started in January and extended to July or later. Embryos were found each month from January until September—most were in March and April. Embryos ranged in number from 1–8, had a mode of 3, and averaged 3.2. Litter size ranged from 1–6, had a mode of 4, and averaged 3.5 kittens. Placental scars ranged from 3–5, had a mode of 4, and averaged 3.9. Bright yellow corpora lutea ranged from 2–9, had a mode of 5, and averaged 4.8 per female. Birth dates of 13 litters extended from March to July; one September pregnancy was noted. Lactating females were found from March until September, the most in May. Kittens a few to several days old weighed from 4.5–11.6 ounces. There was no indication that males help with the care of young. Females are good mothers and will care for kittens under trying conditions, but if unduly disturbed may sometimes desert

the newborn young. Kittens will stay with the female until 2/3 to 3/4 grown. One instance of hybridization between a male bobcat and female domestic cat is reported.

The bobcat, *Lynx rufus*, is one of the larger predators in Utah and is found over most of the state. Although found from the lowest to the highest elevations, it prefers the rocky country near the upper edge of the foothills. Bobcats are relatively abundant and undoubtedly have considerable impact on other animals living within their habitat.

From 1950 to 1955, we were engaged in a big game-study which afforded an opportunity to accumulate considerable additional information on the bobcat. The data presented herein should add to our knowledge of the bobcat and lead to better management of the species.

METHODS

A group of government hunters was supplied with forms on which to record detailed information on the bobcat; their monthly reports were a source of many data. The government hunter itineraries from 1915 to 1958, on file at the District Agent's Office, also proved to be a fertile source of information. Several private hunters contributed data in addition to our observations.

RESULTS AND DISCUSSION

Sex ratios.—Data were secured on 11 litters of bobcats—6 unborn and 5 newborn young about 2–3 days old. The unborn litters had 7 males and 11 females while the newborn litters contained 7 males and 9 females. There were 14 males and 20 females in the combined litters, giving a ratio of 100 males to 143 females. The number of young is too small to be significant; however, it is interesting to note the females outnumbered the males in the sample.

A total of 792 bobcats were sexed in Utah by the group of government hunters, in the period 1950–1955. Of these animals, 416 were males and 376 were females, giving a ratio of 100 males to 90.3 females. In the northeastern states, Pollack (1950) found a sex ratio of 100 : 96 for 180 bobcats. Though there is a difference of about 6 per cent in the two sets of ratios, both show a preponderance of males.

The sex ratio of 28,432 bobcats caught by government hunters from 1915–1956 was 100 males to 77.6 females (Table 1). Males outnumbered the females each month of the year. There was some monthly variation in the number of females, probably associated with such activities as breeding, birth of young, feeding of young, etc. A sample of 8,703 Arizona bobcats similarly gave a ratio of 100 : 79.5 (Young, 1958). However, we do not know how accurately these records for trapped animals reflect the sex ratio of a wild population. Tagging and recapture studies of bobcats by Robinson and Grand (1958) indicate a greater average movement of the male (5.3 miles) than of the female (3.3 miles). The greater movements of the male could produce a bias in the sex ratio of trapped animals because of increased opportunities for capture.

TABLE 1.—*Number of trapped male and female bobcats and percentage of females by months (1915–1956)*

MONTH	NO. MALES	NO. FEMALES	PER CENT FEMALES
January	1,346	1,152	85.6
February	1,318	1,106	83.9
March	1,629	1,264	77.6
April	1,292	855	66.2
May	1,301	1,002	77.0
June	1,361	1,090	80.1
July	977	783	80.1
August	1,060	801	75.6
September	1,230	921	74.9
October	1,533	1,083	70.6
November	1,437	1,136	79.0
December	1,523	1,232	80.9
Total and average	16,007	12,425	77.6

Breeding season.—On 21 and 22 March 1952, George F. Patrick captured two adult female bobcats, one in Browns Canyon and the other on Mustang Mesa, San Juan County. Their vaginas, uteri and ovaries were swollen and inflamed and a male was caught in the traps after each female, suggesting that the females were either breeding or in estrus. Both animals had been chewed around the neck. The mating period is apparently a trying one for the females.

No other direct breeding data on the bobcats were secured. However, Palmer (1954:146) states that the gestation period is 63 days or more. By using the birth date data and figuring backward with the gestation period, we arrived at a rough estimate of when mating started. These data suggest that mating started in January and ended in May. However, Table 2 shows embryo litters in January and September. The January embryo litters were found the last third of the month, so they were probably conceived the same month. Mating must have taken place in July or later for the September

TABLE 2.—*Bobcat embryo litter occurrence by months*

MONTH	NUMBER	PER CENT
January	4	1.1
February	35	9.8
March	137	38.6
April	109	30.6
May	51	14.3
June	11	3.1
July	4	1.1
August	4	1.1
September	1	0.3
Total	356	100.0

litter. Thus the mating period was roughly from January to July or later. Duke (1954) considered the main bobcat breeding season to be the February–April period. However, he found an embryo litter in October, so some bobcats must breed as late as August or later. He also thought the female was polyestrous, i.e., if she failed to become pregnant in early spring, she would come in heat again later in spring or early summer, and the males were probably fecund year-round. The long breeding season indicated in the present study tends to support his theory.

Den sites.—Partial data were secured on four bobcat dens as follows:

On 8 July 1954, Allen B. Robbins and Roy Shane found a bobcat den on the north end of the Mineral Range, Millard County, in which the den entrance was a crevice about a foot wide which extended back in the ledges and the young were 4–5 feet from the entrance.

In November 1923, the late Clark Huff, government hunter, found a litter of four young bobcats in a hollow log. He thought the female was nearby but she did not appear while he was capturing the young. The litter was found near Whiskey Creek, Millard County.

George Rost found a bobcat den with three young during May 1952 in the Oquirrh Mountains, Salt Lake County. The den was a hole in the rocks 2.5 feet in diameter and 4 feet deep and did not have any nest material.

Lavere Kidman reported that during May 1951 Calvin Halestone, a private hunter, took four young bobcats from a den located among the rocks, on the west side of Hansel Valley, Box Elder County.

Three of the dens were in rocky situations and the fourth was in a hollow log; however, bobcats apparently use a variety of den sites. Palmer (1954) indicates the bobcat den is a log, rocky ledge or thicket. Anderson (1945) states that in most cases bobcats den in rocks or under ledges; they often den under heavy brush, under large cedar trees, or in hollow logs.

Embryo occurrence.—Government hunters in Utah normally report the date and number of unborn bobcats in each pregnant female caught. These data are presented in Table 2.

Bobcat embryos were found each month from January until September; most of these unborn litters were found in March and April. In a sample of bobcats from the 11 western states, Duke (1954) found embryos from February until June, and again in October. He also found the highest percentage of pregnancy in March and April.

Litter size.—Information on embryos and newborn young has been compiled in Table 3.

The 356 embryo litters in the present study ranged in size from 1–8, had a mode of 3, and averaged 3.2 young each. Forty-seven newborn litters ranged in size from 1–6, had a mode of 4, and averaged 3.5 young, agreeing quite closely with the embryo litters. Palmer (1954) reported a bobcat litter size of 2–4, often of 3 young. In Massachusetts, Pollack (1950) considered the average bobcat litter to be 2. Grinnell *et al.* (1937) stated that W. H. Parkson

TABLE 3.—*Bobcat litter size classes*

SIZE OF LITTER	EMBRYOS		NEWBORN YOUNG	
	Number	Per cent	Number	Per cent
1	13	3.7	1	2
2	86	24.2	8	17
3	127	35.7	13	28
4	83	23.3	16	34
5	34	9.5	8	17
6	8	2.2	1	2
7	4	1.1	—	—
8	1	0.3	—	—
Total	356	100.0	47	100
Average	3.2	—	3.5	—

considered the average California litter to be 3. Young (1958) states, "The size of the litter of young will average about two, although three or four to a birth is not uncommon." A comparison of the data reveals the Utah litters were as large as or a little larger than those reported for other parts of the country.

The uteri were examined for placental scars, which included distorted places in the uteri caused by embryos stretching the tissues and stained or blood-filled tissues where the placenta had been attached. These indicators are not discernible on all uteri, but when present appear to give accurate data on litter size.

Counts were also made of the number of current corpora lutea present in the ovaries. The ovaries were sliced at several places to give a cross-section view of the corpora lutea so an accurate count could be made. Many ovaries contain what appear to be several age classes of full-size corpora lutea. Duke (1949) thinks that different coloration indicates different age classes, providing the bobcats only breed once a year. In this study only the bright yellow corpora lutea, considered to be of the same age and of the current season, were recorded. Because of the foregoing assumptions, counts of corpora lutea should be accepted with reservations.

Data on placental scars and corpora lutea counts are given in Table 4.

The scar counts ranged from 3–5, had a mode of 4, and averaged 3.9. Because of a very small sample, the range of the scar counts was much more restricted than for the embryos and newborn litters. Placental scar litters averaged more than either the embryos or the postnatal litters.

The corpora lutea counts ranged from 2–9 per set of ovaries; this is greater than was found for the embryos, born litters, or placental scars. The largest embryo litter was 8 compared to 9 current corpora lutea in one set of ovaries. The mode for corpora lutea was 5 and the average 4.8. Both figures are greater than were found for embryos, newborn litters, or placental scars. Although the corpora lutea data are limited, they do suggest that more ova are shed than ultimately develop into embryos.

TABLE 4.—*Bobcat placental scar and corpora lutea group size classes*

SIZE OF GROUPS	PLACENTAL SCARS		CORPORA LUTEA	
	Number	Per cent	Number	Per cent
2	—	—	1	5
3	4	33	5	24
4	5	42	3	14
5	3	25	6	29
6	—	—	2	9
7	—	—	3	14
8	—	—	—	—
9	—	—	1	5
Total	12	100	21	100
Average	3.9	—	4.8	—

Birth dates.—A total of 13 birth dates were secured in this study (Table 5). These were obtained largely from females which bore young while in traps. Additional birth dates were secured from young litters that were found in dens and could be aged rather accurately.

The birth dates extended from March to July, with the majority of them occuring in April and May. Since Table 2 shows an embryo litter for September, a larger and more representative sample would probably reveal litters also born in August, September, and possibly October.

Lactation period.—Fifty-eight lactating females (Table 6) were found from March until September. Most were secured during May, although there were also good numbers in April and June. Young (1958) indicates that females nurse their young for a period of about two months.

The young.—The kittens are born with their eyes closed; no information was obtained on the length of time it takes them to open. Grinnell *et al.* (1937) indicated that the kitten's eyes open in 10–11 days. Pollack (1950) gives an example of a young bobcat which was at least 11 days old when its eyes opened. Palmer (1954) states their eyes open in 9–10 days. Young (1958) indicates their eyes open in 3–9 days.

The weight of newborn kittens also seems to vary considerably. Allen B. Robbins of Salt Lake City and Roy Shane of Provo had two captive kittens whose eyes opened on 11 July 1954. On 14 July they were weighed when

TABLE 5.—*Number and percentage of bobcat birth dates by months*

MONTH	NUMBER	PER CENT
March	1	7
April	4	31
May	4	31
June	1	8
July	3	23
Total	13	100

approximately 13 days old. At that time one weighed 11.6, the other 8.5 ounces. During March 1953, Mrs. Deringer of Rock Candy Mountain weighed two kittens which still had their eyes closed; both weighed 8 ounces. On 13 April 1951, James M. Gray caught a female which gave birth to a litter while in a trap near Jackrabbit Spring, Iron County. The two kittens, which were probably three days old, weighed 4.75 and 4.5 ounces. Young (1958) indicates that newborn kittens weigh 10–12 ounces, with the female weight being nearer 10 than 12 ounces. Palmer (1954) gives their weight as 12 ounces. Pollack (1950) states that a recently born kitten weighed 12 ounces. From this it appears there is quite a range in the weight of newborn kittens. However, the Utah young were weighed from a few to several days after birth and they may have lost weight. In the case of the trapped female which gave birth to young, it is possible her thrashing around in the trap caused them to be born prematurely.

Parental care.—No evidence was secured that the male helps with the care of the young. However, Young (1958) states, "Both parents bring food to the kittens before and after the den is abandoned." Females are apparently model mothers—there are several instances of their giving birth to young while trapped and giving the young the best care possible under the circumstances. On the other hand, there is one case of a female eating her kittens which were born while she was trapped.

Although bobcats seem to take good care of their newborn young, the adults have a strong fear of man and dogs. When approached by them, bobcats often run off and leave their helpless kittens without showing any evidence of fight. An example of this behavior was reported by Allen B. Robbins of Salt Lake City and Roy Shane of Provo. On 8 July 1954, while prospecting on the Mineral Range in Millard County, they found a bobcat den with young. Robbins had passed by the crevice and Shane had passed and was about 6 feet away when the mother emerged. She showed no inclination to fight and fled up through the ledges.

When the kittens get larger and are able to move about, at least some of the adult females display hostility if the kittens are threatened. An example was related by Ben Merchant. During the deer season in November 1948,

TABLE 6.—*Number and percentage of lactating bobcats by months*

MONTH	NUMBER	PER CENT
March	1	2
April	16	27
May	19	33
June	14	24
July	6	10
August	1	2
September	1	2
Total	58	100

Merchant and his son were hunting on the North Fork of Tanner Hollow, Beaver County. They were sitting on a rock when suddenly they noted a female bobcat coming up a trail followed by two playful kittens the size of house cats. The female was within 25 feet of the men before she noticed them. She stopped and snarled at the men and seemed prepared to attack. The kittens hid when the female snarled; they were not seen again even when she went over a ridge.

Bobcat young often stay with the female until they are fairly well grown. Willis Butolph told of catching a female and her five kittens which were ⅔ to ¾ grown, in January 1950, on Fish Creek, Carbon County. Butolph also stated he had captured young with their mothers on several occasions after snow was on the ground. During November 1948, Ray Robinson, a private hunter, observed the tracks of kittens which were estimated to be one-half adult size with those of the female on Buckskin Mountain, Beaver County.

Hybridization.—Golden Peay, in charge of law enforcement for the Utah Fish and Game Department, relates the case of several of his house cats disappearing, one by one, in the spring of either 1934 or 1935. One female later returned, followed by five kittens—three like bobcats and two like ordinary house cats. The bobcat kittens were darker than might be expected but their tails were short and they had tufted ears and white bellies with black spots. The two domestic-type kittens were yellowish and had long tails. The mother kept the kittens beneath the house and all of them were very wild. About weaning time the domestic kittens disappeared. One of the bobcat-like kittens disappeared shortly afterward, but the other two remained for about a year. They were excellent mousers and, surprisingly, did not bother the poultry. They could never be petted although they could be approached within a few feet. They looked like bobcats except they did not get so large—not much bigger than a large male house cat—and were darker.

Young (1958) gives two instances of matings between bobcats and domestic cats. In each of these three available records the male bobcat mated with the female domestic cat.

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A small amount of the data for 1950–1954 was also published by Young (1958).

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FURTHER STUDIES ON LOCOMOTION OF THE CHEETAH

BY MILTON HILDEBRAND

ABSTRACT: A high-speed motion picture camera was used to record the gaits of a captive cheetah. A previous study (Hildebrand, J. Mamm., 40: 481–495, 1959) is corrected (in regard to estimated speed and rate of stride) and new data presented on motions of the body at the walk, trot and gallop. The slow gallop (± 33 mph) differs from the fast gallop (± 56 mph) in that stride is shorter (though scarcely slower), and also in the use of the spine, duration of the support periods, placement of leading feet and paths followed by the feet between footfalls.

Sharp flexion of wrist and ankle joints as their respective girdles pass over them is described and interpreted. The legs are extended relatively far forward (compared to horse) when they strike the ground. Frequent change of lead and sudden stops are described. The sequence of footfalls, phases of the stride and their duration are figured for the walk, trot, slow gallop and fast gallop. Motions of the scapula are described for a walking animal.

MATERIALS AND METHODS

At Ocala, Florida, John Hamlet has an animal show that includes a cheetah trained to run in a 65-yard-long enclosure. For rewards of meat the animal runs after a paper bag tied to a long cord that is reeled in with an adapted bicycle wheel and crank. The cheetah appears to regard the performance as a game: the observer feels that it could catch the bag at will; yet, although the cat may run beside the bag or even win the race, the bag is seldom touched till the end of the run. Usual maximum speeds are about 33 mph. As has been noted (*op. cit.*: 482), published claims of significantly greater speed for this cheetah are in error.

The animal was photographed by the author with a Trade 200 electric camera that takes 200 frames per second at exposures of 1/1000th of a second. The grass on the course was cleared out sufficiently so that the cheetah's feet

could be seen when in contact with the ground. Chalk lines were placed across the track at exact, 5-yard intervals. Thus, since the camera speed is known, the animal's speed can be calculated directly from the film. Ten runs were photographed, and two sequences of walking and two of trotting.

Thanks are due Mr. Hamlet for his willing cooperation in this project. I am also indebted to Walt Disney Productions for furnishing, from the film "African Lion," an excellent close-up sequence of a walking cheetah.

The method of study was as described in the previous paper; clearer and more detailed images, however, permitted easier and more precise analysis.

CORRECTIONS

My first paper on the running cheetah was based on a film sequence obtained from Walt Disney Productions. Estimate of the animal's speed was based on an assumed body length of about 7 feet and a reported film speed of 48 frames per second. It was not until the article was in press that the photographer, Alfred Malotte, who had been abroad, corrected the studio's figure and informed me that the film speed was actually 64 frames per second. Estimate of maximum speed is changed from about 42 mph to a more respectable (for a cheetah) 56 mph, and duration of stride (or cycle of motion) becomes .28 second, or about 3½ strides per second. Further, I stated (*op. cit.*: 491) that the cheetah adds about 15 in. to each stride by a measuring-worm motion of the spine. This should have been 15 in. *two* times per stride (when the spine is being flexed and again when it is being extended). With the revised estimate of stride rate, the benefit to speed when the animal is running fast becomes about 6 mph.

NEW FINDINGS

Nature of stride in relation to speed.—From the Disney film it was evident that the animal in Florida was by no means extending itself. This circumstance is at first disappointing, but it permits a contrast between the ways that the cheetah runs at different speeds.

For each of nine runs, speed was determined over the 5-yard interval most favorable to accurate observation (when the animal was side-on to the camera). The slowest speed was 27.7 mph, the fastest 37.5 mph, and the average 33.0 mph. Nine determinations of rate of stride indicate that one cycle of motion was completed variously in .34 to .29 second, averaging .31 second. Within these limits there is little correlation between rate of travel and rate of stride. Five determinations of length of stride range from 12 to 16½ ft, averaging 14.3 ft. (The corresponding speeds average 30.5 mph.)

My previous study (as corrected) established that at about 56 mph the cheetah completes one stride in about .28 second and averages roughly 23 ft per stride.

We may conclude that length and rate of stride vary even at a single rate of travel, but that, as the cheetah accelerates from about 33 to about 56 mph,

its stride rate increases only slightly, whereas its stride length increases considerably.

Galloping carnivores increase their speed by alternately flexing and extending the spine. When its body was flexed, the chest-rump length of the fast-running Disney cheetah was only 67 per cent of the extended chest-rump length. As expected, eight determinations for the Florida cheetah show that the activity of the spine was less extreme at the lesser speeds: chest-rump length of the flexed body averaged 73 per cent of the length of the extended body.

Four other differences between the way the animal runs at 33 and at 56 mph relate to the placement of the feet and the duration of the various phases of the stride (a phase is a particular combination of supporting members or an unsupported period). These differences are illustrated in Fig. 4. (1) The Disney cheetah was supported by one or more feet during about 54 per cent of stride duration; the support period of the Florida animal was variable but always greater than 54 per cent of the stride, averaging 68 per cent in six records. (2) The trailing front foot (first of the pair to strike the ground in each stride) of the Disney cheetah appeared to be lifted again about the moment that the leading foot struck the ground—indeed, although the exact instant when the feet touched the ground was difficult to determine, I suggested tentatively that there was a fleeting instant between the support periods of the two front feet. The Florida cheetah, on the other hand, did not reach out so far in placing the leading front foot: the two feet were on the ground simultaneously for 19 per cent (average of five records) of the total interval between the strike of the trailing foot and the lifting of the leading foot. (3) Similarly, both hind feet of the Disney cheetah were on the ground simultaneously for only about 23 per cent of the interval between the strike of the trailing foot and the lifting of the leading foot, whereas the Florida cheetah increased this figure to 39 per cent (average of six records) when running at 30 to 35 mph. When traveling more slowly than 15 mph it commonly placed the hind feet at nearly the same instant, in the fashion of the half-bound of domestic cats. (4) The leading feet (front and hind) of the Florida cheetah

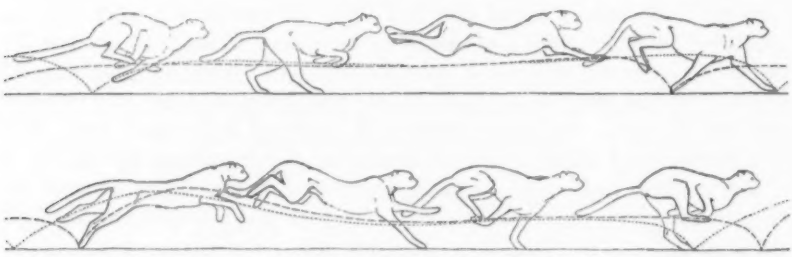

FIG. 1.—Eight positions of a cheetah galloping 50 to 60 mph. Trajectories followed by the front feet are indicated above, those by the hind feet below, long dashes for right feet and short dashes for left feet.

supported the animal about as long as their opposites—in any particular stride either a leading or trailing foot might have the longer contact with the ground. This observation is somewhat at variance with my previous conclusions on the Disney cheetah. Whether the discrepancy is due to the difference in speed or to inadequate data I cannot say, but quite possibly the latter is partly responsible: the more one studies the gaits of animals the more one is impressed by the range of variation.

The trajectories, or paths, followed by the feet in relation to the ground are shown for the fast-running cheetah in Fig. 1. The slower-moving cheetah displayed similar trajectories, but without lifting the feet so high. In particular, there is much less follow-through of the hind feet, and the front feet do not reach nearly so high before returning to the ground.

The Florida cheetah has an exceedingly variable body posture at the speeds studied. In approaching the bait closely it may run in a low crouch with legs partly flexed and motions of the spine in the vertical plane restricted. Other runs are made with shoulders and pelvis alternately bouncing up and down in the extreme. The cat runs easily while looking back over one shoulder, and on occasion runs slowly sidewise by alternately bouncing the fore- and hindquarters to one side. The observer is impressed by the animal's agility, flexibility, coordination, and lithe flowing motions.

I had hoped to record acceleration rates for fast starts—such records are almost completely wanting for cursorial animals. This cheetah, however, to start its run, turns into the track from a position to one side and does not get under way with a sudden burst of speed.

Other motions of legs and feet.—The wrist and ankle joints of the running cheetah, as their respective girdles pivot over them, are sharply flexed. When the forearm is vertical it forms an angle of about 110° with the axis of the

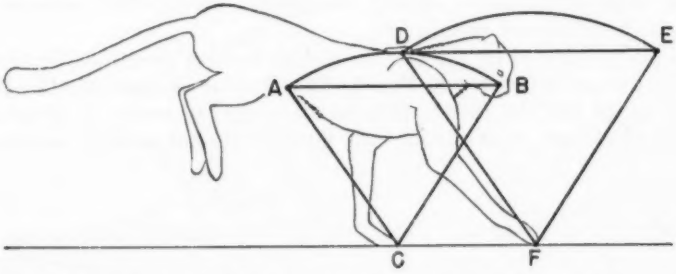

FIG. 2.—Relation of motions of the scapula and wrist joint to the path followed by the spine at the shoulder. *DC*, functional length of leg when in flexed, or shortened, position; *DF*, functional length of leg when in the extended, or lengthened, position. Arc *AB* = path of spine, and chord *AB* = advance of body if leg were held rigid in the flexed position while supporting the body. Arc *DE* = path of spine, and chord *DE* = advance of body if leg were held rigid in the extended position. Chord *DE* also = both actual path of spine and actual advance of body as the leg is alternately extended, flexed and extended again while the shoulder moves forward.

front foot, and when the pelvis passes over the heel, the shank forms an angle of 85 to 90° with the axis of the hind foot. Figure 1 is a revision of a figure in my earlier paper (*op. cit.*: 487) to show the feet positions more completely and accurately. Marked flexion of these joints is of considerable importance in two ways: (1) A forward thrust is achieved by the extension of each foot just before it is lifted from the ground. This adds both power and velocity to the stride. (2) Flexion of these joints shortens the limbs just as their respective girdles pivot over them, thus permitting the girdles to move forward without rising and falling in arcs centered at the feet, as would be the case if all joints of the leg were held rigid while the feet pivoted on the ground. This is a factor of particular importance when the limbs strike and leave the ground at relatively acute angles to the ground line (see next paragraph), because then, if the limbs were not shortened, the girdles would follow larger arcs and twice in each stride would rise and fall markedly (Fig. 2).

I have suggested that one way the cheetah achieves a stride that is longer, relative to body size, than that of the horse is by reaching out farther, front and back, as the feet strike and leave the ground. This point can now be detailed further. When each is running at 30 to 35 mph, the angle made by the leg (front or hind) with the ground line at the moment the foot is lifted from the ground is nearly the same for the two animals, though probably slightly greater for the horse; the corresponding angle when the feet (again front or hind) strike the ground, however, is more acute for the cheetah by about 12°.

I have postulated that the front feet of the hard-running cheetah have enough backward force when they are on the ground to develop a traction that prevents any deceleration of the body as the spine is flexed on itself. Efforts to verify this point for the Florida cheetah are somewhat inconclusive: in some instances the front feet had no forward motion in relation to the ground immediately before striking the ground, and in other instances they retained slight forward motion.

The paths followed by the feet in relation to fixed points at the shoulder and the hip are contrasted in Fig. 3. The drawing is based on the Disney animal except that the Florida film has been used to verify the positions of the feet when near, or in contact with, the ground—not an ideal analysis, but

FIG. 3.—Paths followed by the feet of the cheetah in relation to approximate limb pivots at shoulder and hip.

probably within the limits of variation. The cheetah lifts its feet higher, reaches the feet out farther to the front and rear, and maintains relatively longer contact of the feet with the ground than does the horse.

Change of lead.—It was learned from the Disney film that the running cheetah changes lead frequently and easily. I surmised that lead was changed because of irregularities of terrain or changes in the direction of travel, but the Florida film demonstrates that the cheetah frequently changes lead even when running on a straight and unobstructed track. Each run required only six to eight strides (excluding turns at the start and end of the course), yet lead was changed, on the average, once in each run.

Stopping and turning.—When running straight ahead, the cheetah requires but a single stride to stop from an estimated speed of at least 20 mph. The two front feet first come down at about the same instant and then the two hind feet. All four feet are placed far to the front and the toes are spread.

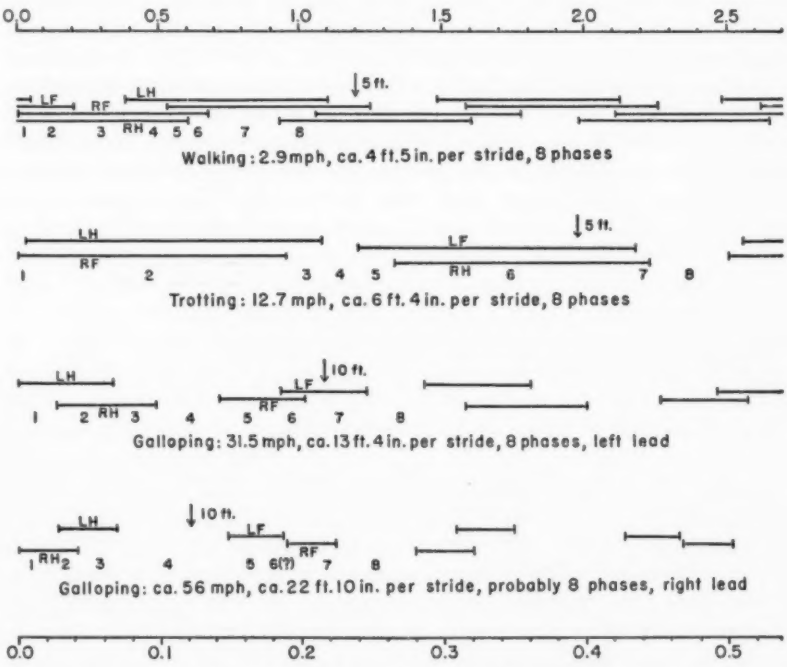

FIG. 4.—Sequence of footfalls and phases of representative strides of the cheetah shown in relation to time in seconds. Letters *R*, *L*, *H* and *F*, respectively, mean right, left, hind and front feet. The period that each foot is on the ground is shown by the length of its respective line. Upper time scale is for walking gait; lower time scale is for other gaits. Time intervals required to cover specified distances are indicated. Phases of the strides are numbered.

In Florida the sandy soil sprays widely, and repeated stops create a trough that must be filled from time to time.

This cheetah also enjoys finishing a run with a remarkably sharp turn around a tree that stands beside the end of the course. On these runs the animal's body leans into the turn to such an extent that its dorso-ventral axis forms an angle of only about 29° with the ground (average of four records).

I looked in vain for a correlation between lashings of the long tail and maneuvering of the body. The tail was often raised just before a turn, yet did not consistently perform any particular motion during sharp turns.

Walking and trotting.—Figure 4 shows, for representative strides at the walk and trot (and gallop as already noted), the sequence of footfalls, phases of the strides and duration of the phases. The data are accurate for the strides represented; variation is considerable, however, when consecutive strides are compared. For any particular stride, at either gait, either the front or hind feet may have slightly the longer contact with the ground. Each gait has eight phases. The trot is erect, symmetrical and springy; the body is supported by one or two feet at a time, or is unsupported. In the walk the body may be supported by two, three or four feet.

A close-up film record made it possible to study in some detail the motions of the shoulder of the walking animal. One could identify the positions of the vertebral border of the scapula, the greater tuberosity of the humerus and parts of the long head of the triceps, acromiodeltoid and supra-spinatus

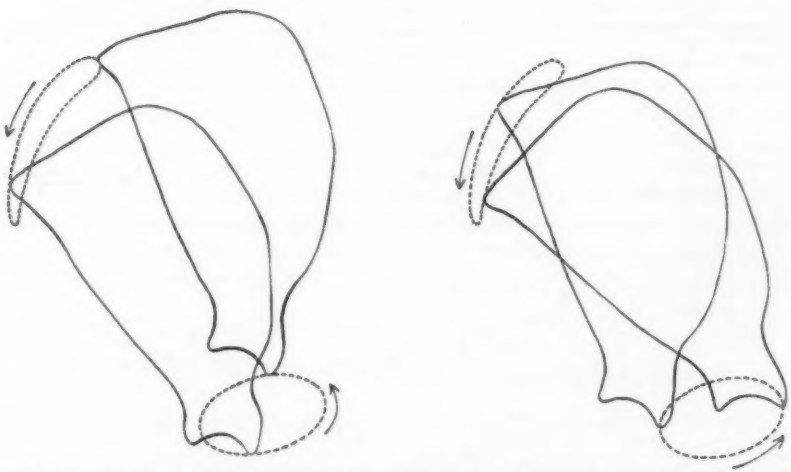

FIG. 5.—Motions of the scapula of the walking cheetah shown in relation to a fixed thorax. LEFT FIGURE: weighted (upper) and unweighted positions. RIGHT FIGURE: positions when leg is extended forward and backward. Paths traced by the coracoid process and posterior angle of vertebral border are indicated. The magnitudes of the motions are given in text.

muscles. Guided by these features, a clear plastic silhouette of the scapula, cut to exact scale, was positioned in turn over successive images projected on tracing paper, and outlines of the scapula were drawn. Certain markings on the pelt at the base of the neck and on the side of the thorax were selected as reference points so that successive drawings of the scapula could subsequently be superimposed to reveal the motions of that bone with reference to a fixed thorax. These motions are shown in Fig. 5.

One is impressed by the extent of the motions: the coracoid process describes an oval that is about 2¼ in. long by 1¼ in. high; the posterior angle of the vertebral border describes a crescent that is about 3½ in. long and ⅝ in. in maximum width. Each end of the right scapula makes its circuit in a counter-clockwise direction.

Clearly, the horizontal travel of the glenoid cavity is incorporated into the length of the stride. Since each shoulder blade contributes once in each full cycle motion, each stride is lengthened by about 4½ in.

The scapula rotates in the vertical plane through about 26°. (The thorax of the walking animal rotates little in this plane, therefore the motion must be attributed to rotation of the scapula on the thorax.) The magnitude of this rotation somewhat exceeds my estimate (based on less favorable material) of the equivalent motion of the running cheetah (*op. cit.*: 489), which, therefore, was probably too conservative.

It was noted that, to prevent marked up-and-down motions of the spine, long-striding animals must shorten their limbs materially as the respective girdles pass over them. Further, it was shown that carnivores accomplish this shortening largely by flexing the wrist and ankle joints. (Ungulates flex the fetlock joints.) This method of shortening is sufficient for the hind limb of the cheetah, but not for the forelimb, which has a shorter foot. It is seen from Fig. 5 that the glenoid cavity is carried about ¾ in. higher when the limb is under the body (midway in the weighted part of the cycle) than when the limb is extended to the front or rear. This additional shortening of the leg permits the thorax to glide smoothly forward without rising up over the supporting leg.

The vertical travel of the vertebral border of the scapula is even greater—about 3 in. at the posterior angle—than the vertical travel of the glenoid cavity. When in the elevated position the vertebral border of the scapula is well above the neural spines and passes slightly across the midline of the body to a position directly above the same border of the depressed scapula of the other side. One can scarcely force one's fingers down between the two shoulder blades, and then only if the hand is slanted down under the higher bone of the weighted side. As the walking animal is viewed from behind, the rise and fall of the shoulder blades is striking, as is the way in which their upper margins alternately cross over the sagittal plane.

Dept. of Zoology, Univ. of California, Davis. Received 31 May 1960.

NOTES ON MAMMALS FROM NEBRASKA AND SOUTHWESTERN IOWA

By Ralph Velich

Abstract: Notes of historical, distributional, and general natural history interest are presented for twelve Recent and one fossil species of mammal that have come to my attention in the taxidermy business at Omaha, Nebraska.

The following notes concern some observations on mammals and materials which have been added to my personal collection as study skins or mounted specimens. It is my hope that there will eventually be a natural history museum in Omaha where my collections of mammals, many now extinct or rare in the state, will find a permanent home.

Scalopus aquaticus machrinoides Jackson.—On 8 July 1959, T. M. Hodgin of Lincoln, Nebraska, brought in a large-mouth bass for mounting. The stomach contained a full-grown mole; the tail and one hind foot had been partly digested, and only the skull was preserved. This specimen was taken at 11:30 PM in the middle of a lake at Linoma Beach, Ashland, Lancaster County, Nebraska. It is not uncommon to find a mouse in the stomach of a bass, but a mole as prey is of unusual interest.

Sylvilagus floridanus mearnsi (J. A. Allen).—Since my last report on the black eastern cottontail (J. Mamm., 39: 148, 1958) a number of specimens have been taken in the De Soto area of the Missouri River, Washington County, Nebraska. At least 16 kills have been reported, most of which I have examined. The color varies from a deep jet black to a sooty gray. This strain of black rabbits is apparently well established; I have preserved a number as study skins or mounted specimens. A record of a black rabbit from a different area was secured when Frank Kingston of Omaha shot one on 30 December 1956, approximately 3 miles south and 2 miles west of Lincoln, Lancaster County. This specimen was not preserved, being regarded as inedible.

In the Omaha *World Herald* of 20 January 1936 is an account of a black cottontail shot by R. A. Bloedel and Glen Wetherhead of Tabor, Page County, Iowa. The rabbit was given to game warden L. F. Kiner of Shenandoah, Iowa; he sent it to game technicians at Des Moines, who had it mounted.

Tamias striatus griseus Mearns.—There are two additional records of the gray chipmunk in eastern Nebraska. A colony may be found about 1 mile south of Nebraska City, Otoe County, along the Missouri Pacific Railroad tracks. Joseph Voges of Nebraska City tells me that this had been an extensive colony during the depression years, but that the animals have recently become scarce. Another colony may be found along the same railroad approximately 5 miles south of Nebraska City, adjoining the farms of William Rowan and John Crook. I have one study skin of a male taken in this area in June 1948.

Sciurus carolinensis Gmelin.—On the authority of Joseph Voges of Nebraska City, Otoe County, there are two thriving colonies of gray squirrels within 3 miles of that city. They were first noted in this area four years ago and seem to be increasing.

Castor canadensis missouriensis Bailey.—On 18 April 1959, on Highway 30 about a mile east of North Bend, Dodge County, Nebraska, I found a female beaver recently killed by a car. The animal was still warm when picked up at about 10:00 AM. This is the first time I ever found a beaver killed by a car; the nearest water was the Platte River, half a mile distant. I mounted the specimen which is now in the Smoky Hills Historical Museum at Salina, Kansas.

Late in the 1959 beaver trapping season, Norman Lorenz of Osmond, Pierce County, Nebraska, trapped a white beaver weighing 20 pounds. The animal had blue eyes and a dark brown spot, about the size of a quarter, on the left hind leg. The sex was not determined.

Myocastor coypus (Molina).—The first nutria taken in Nebraska was a female collected by Fred Scott, Jr., at the Aldy Foster farm near Max, Dundy County, on 17 December 1944. It weighed 14 pounds and was mounted for the University of Nebraska State Museum.

Late in November 1957, Loyal W. Johnson of Nebraska City caught a 14½-pound nutria in a trap set for beaver, on the Iowa side of the Missouri River in Fremont County, just across the Nebraska City Bridge. In late December 1958, Edward Dostal of Omaha brought in a male nutria found dead in a trap, just north of Bellevue on the Gifford Tract, Sarpy County, Nebraska. This animal was in fine physical condition and was estimated to weigh 20 pounds.

The Omaha *World Herald* of 31 July 1956 carried a note that the Omaha City Council contemplated introducing the nutria into Carter Lake from St. Petersburg, Florida, in order to "clean the lake of excessive vegetation." No definite action had then been taken, but this may suggest in part how the species has extended its range so rapidly.

Urocyon cinereoargenteus (Schreber).—A female gray fox was trapped by Jack Kraus, Sr., on the Don Davis farm at Almeria, Loup County, Nebraska, on 10 December 1959. This specimen was brought in, by Dr. H. L. Van Armburg of Sargent, for mounting. I saved the fragmentary skull.

Recently, in the Washington County (Nebraska) Historical Museum, I came across a mounted gray fox labeled "rare red fox," together with the notation that it was shot in Washington County. Miss Edith Neale, director of the museum, has helped me uncover the facts that this fox was killed by Sam Gearhart and Judge Walton in the De Soto Woods near Fort Calhoun, Washington County, in September 1894. It was the first of its kind seen in this area. The mounted fox, of unknown sex, was given to the museum by Walter Sappenfield of Fort Calhoun, grandson of Gearhart.

Mustela nigripes (Audubon and Bachman).—I recently was able to acquire a fine mounted female black-footed ferret, taken in 1938 near Anselmo, Custer County, Nebraska. Other details are lacking.

Lutra canadensis interior Swenk.—Presently I expect to add to my collections a fine mounted specimen of the native Nebraska river otter, mounted by John E. Wallace, an Omaha taxidermist, at the turn of the century. Details of its capture are unknown but, according to Wallace, it was taken from the

Missouri River near Omaha. This specimen was sold to the Jetters Brewery Museum, where I first saw it, and where it remained until the exhibits were sold during the depression years. Some of the mounted specimens were sold to a tavern at 24th and L Streets, and a few years ago this material was consigned to the city dump. Some of this material I was able to salvage, and other items were acquired by the man who then operated the dump.

Cervus canadensis canadensis (Erxleben).—Sharpe Osmundson of Council Bluffs, Iowa, gave me the right antler fork, in a fine state of preservation, of a six-point elk he found washed out in a creek near the Waubonsie State Park in Fremont County, Iowa, after the 1952 flood. I also have a cranium and about 2 feet of each antler, from the brow tines, of a specimen collected by Don Craig of Blair, Nebraska, along the Missouri River bluffs about 6 miles south of Blair, Washington County.

Odocoileus hemionus hemionus (Rafinesque).—The white-tailed deer is quite common in eastern Nebraska, but there now are also definite records of the mule deer, though extremely rare. In the fall of 1957, Bill Nestroyl of Omaha reported a set of antlers from a mule deer killed by a car about 3 miles south of Bellevue, Sarpy County. On 24 May 1959, I found a doe, killed by a train, on the east side of the railroad tracks, 30 yards east of Big Pipe Springs in the Fontenelle Forest, Sarpy County. The skull was preserved.

The first record, to my knowledge, of a mule deer in Washington County, Nebraska, was reported in the Omaha *World Herald* of 27 March 1960. Kermit Dybsetter, manager of the De Soto Bend Wildlife Refuge on the Missouri River, was cited as stating that there were 160 white-tailed deer and one male mule deer on the refuge.

Bison occidentalis F. Lucas.—The cranium of a fossil bison was given to me by Hans Peterson of Council Bluffs, Iowa. This specimen was collected in Indian Creek just north of Council Bluffs, Pottawattamie County. The cranium was identified by Morris F. Skinner of Ainsworth, Nebraska, who states that it is of very late Pleistocene age. The animal was a young male. Other bison skulls have been found in the immediate area, but I have not examined them to ascertain if they too are fossil. In my collection is a horn core of this type of bison, found near Wayne, Wayne County, Nebraska. In addition, I have a cranium with one horn sheath intact and several horn cores of this species taken in 1948 near Cambridge, Furnas County, Nebraska. A left horn core from near Waubonsie State Park, Fremont County, Iowa, was collected on 6 March 1951.

Ovis canadensis auduboni Merriam.—While excavating for a building at the Chadron State Park, Dawes County, Nebraska, Jake Snodgrass dug up the cranium of an Audubon mountain sheep. It is a male in fine state of preservation, and was given to me on 22 March 1948, a week or so after it was collected. This race is now considered extinct.

5212 S. 23rd Street, Omaha, Nebraska. *Received 28 December 1959.*

GENERAL NOTES

FALL BREEDING ACTIVITY OF A YOUNG SHREW

The reproductive activity of shrews is poorly known. Most authors concur that the average life span is short—12–18 months. Hence the age when shrews mature sexually and the length of the annual breeding season are of biological significance. Generally it is believed that the breeding activity of the masked shrew, *Sorex cinereus*, begins in March and continues into September. J. C. Moore (Ecology 30: 234–237, 1949) summarizes the breeding records of 15 pregnant or lactating masked shrews. One was obtained in April, five in June, two in July, four in August and three in October. The three records for October were, respectively, from Pennsylvania, Ontario and Manitoba.

On 15 October 1959, Marvin E. Cooley of the Michigan Department of Conservation found a female masked shrew on the Rose Lake Wildlife Experiment Station, 5 miles east of Bath, Clinton County, Michigan. The shrew was underneath a road-killed raccoon, *Procyon lotor*. Presumably the shrew had gone to the kill and was herself killed when the raccoon was struck by a vehicle a second time. Laboratory examination that afternoon proved the shrew had ben lactating. Milk was not expressed from the teats but the lower abdominal and inguinal surfaces were visibly distended and the teats visible. The body weight was approximately 5.5 grams and the mammary tissue was white and flaccid in appearance and, when dissected free, weighed approximately 0.5 grams. No examination was made for possible lactational pregnancy. The skin and skull (No. 4261) are on record at the Michigan State University Museum.

Microscopic examination of the teeth showed that (1) the unicuspids were worn on their posterior surfaces, the wear arching up over the tips of the unicuspids, and (2) there was wear on the paracones and metacones of M_1 and M_2, with a ridge of wear along the extent of M_1 and M_2. This tooth-wear is interpreted as corresponding to the Class 2 category of Pruitt (J. Mamm. 35: 34–39, 1954) and of Rudd (J. Mamm. 36: 323–339, 1955). According to Rudd, shrews 24–30 weeks of age have this amount of tooth-wear.

Finding no published data on the reproductive periods of the masked shrew, I have applied the figures of Conaway (J. Mamm. 39: 507–512, 1958) obtained from captive least shrews (*Crytotis parva*), of a gestation period of 21–23 days and a lactation period of 21 days in order to try and gain an approximate estimate of the date of implantation for this masked shrew. The only justification for such action is that Conaway lists the gestation periods of several shrews—*Sorex araneus*, *Blarina brevicauda* and *Crytotis parva*—as being similar. Assuming that the lactation period was half complete, the young of my specimen were possibly born on 5 October, and a 22-day gestation period would indicate that implantation occurred on about 14 September. Thus, if the age estimate is reliable, sexual maturity might have been achieved by 20–26 weeks of age. This indicates that breeding in the first year does occur.

So far as I can determine, this breeding record is only the fourth recorded in the literature for the autumn season. This may indicate that the amount of breeding activity in the autumn is not large. Whether autumn breeding is restricted only to some early spring-born individuals or occurs as a small incidence of activity throughout the total population is not known. Rudd (*op. cit.*), for the *Sorex ornatus–sinuous* group of the San Francisco area, states that it is probable that young which appear in late summer or early fall are either (1) born to the last year's late autumn-born females which did not breed until the following late spring or early summer, or (2) were born to a few young-of-the-year females, themselves born early in the spring and sexually mature in their first autumn. Rare or common, however, the indication that masked shrews born in the early spring produce young in their first fall is still another aspect of the population dynamics of this species that is inadequately known.—Henry L. Short, *The Museum, Michigan State Univ., East Lansing.* *Received 19 November 1959.*

AN ALBINO SHREW FROM OHIO

On 16 April 1959, Robert M. Lyon observed a small, white animal running away when he turned over a piece of canvas on the ground in his orchard. He quickly stepped on it, and kept it in captivity for several hours before it died. The following day it was brought to the biological laboratories of Kent State University where it was determined to be an almost completely albino male specimen of *Sorex cinereus ohionensis*. The site of capture was on Hughes Road, 1.25 miles northeast of Edinburg, in Portage County, Ohio. Many runways were found under the piece of canvas, but no other shrew was observed. Sixteen days later, two immature shrews were captured in a compost pile about 100 feet away, but these were normally dark-brown in color. Measurements of the albino specimen are as follows: Total length, 94; length of tail, 23; length of hind foot, 13 mm; weight, 10.11 grams. The tail is about one-third shorter and the hind foot is somewhat longer than usual for *S. c. ohionensis*, according to the measurements given by Bole and Moulthrop when they described this subspecies (Sci. Publ. Cleveland Mus. Nat. Hist. 5 (6): 89–95, 1942).

Against ordinary backgrounds this specimen looks white, but against a pure white background it has a tinge of gull-gray. The only evident pigment is confined to the teeth and eyes. The incisors and eyes are black, while the unicuspids are chestnut brown. Van Gelder (J. Mamm., 40: 438, 1959) has recently pointed out that "albinism in the genus *Sorex* is rare."

The albino specimen has been given to the Cleveland Museum of Natural History. Thanks are given to B. P. Bole, Jr., of Western Reserve University, and the staff of the Cleveland Museum of Natural History for their assistance.—Ralph W. Dexter, *Dept. of Biology, Kent State Univ., Kent, Ohio.* *Received 22 December 1959.*

NEW ARIZONA LOCALITY FOR THE DWARF SHREW

On 14 August 1959, a specimen of *Sorex nanus* was collected near Hannagan Meadows in the White Mountains of Greenlee County, Arizona. This specimen was carried into the camp of W. J. McCauley by his small dog. The campsite was in an area of grassy meadows surrounded by forests of spruce, fir and pine at an elevation of 9200 feet. The external measurements (in mm) are: Total length, 85; tail length, 36; hindfoot length, 11; weight, 2.3 grams. The skull was partially damaged, but certain cranial measurements (in mm) are: Maxillary breadth, 3.5; condylobasilar length, 13.8; palatal length, 5.6; least interorbital constriction, 2.7; length of upper toothrow, excluding I_1, 5.1. The skin and partial skeleton are preserved as No. 3000 in the Museum, Department of Zoology, University of Arizona. The specimen had been transported for two days in an ice chest and decomposition precluded determination of the sex. I am indebted to H. W. Setzer of the Smithsonian Institution for verifying the identification of this shrew.

L. Schellbach (J. Mamm., 29: 295, 1948) reported the first record of the dwarf shrew in Arizona. This specimen was captured in September 1937, nine miles east of Swamp Point, while it was running along a fallen tree trunk. This locale is within the Grand Canyon National Park at an elevation of approximately 8000 feet. The second published record was that of D. F. Hoffmeister (Plateau, 28(1): 4, 1955) in which he reported a mummified specimen found at Kaibab Lodge, VT Ranch, Kaibab National Forest, in April 1944, when a dwelling was first opened after the winter vacancy. The collecting sites of these two specimens are separated by a distance of approximately ten miles. The Grand Canyon National Park study collection is the depository of these two specimens, and they bear catalogue numbers M-372 and M-150, respectively. This note now records the third known record for Arizona, and extends the geographical range to the southeast by approximately 240 airline miles.—Gordon VR. Bradshaw, *Dept. of Zoology, Univ. of Arizona, Tucson.* *Received 6 November 1959.*

SOUTHERN YELLOW BAT FROM ARIZONA

The southern yellow bat, *Dasypterus ega,* is known primarily from Mexico southward into South America. In western Mexico, specimens have been taken from the southern half of Baja California, and on the mainland as far north as Pericos, Sinaloa (Hall and Kelson, The Mammals of North America, 1959, p. 194). Constantine (Bull. S. Calif. Acad. Sci., 45 (2): 107, 1946) reported a single specimen (an adult female, now number 8153 in the Los Angeles County Museum) that was taken as it attempted to fly against a wind in the daytime, on 3 November 1945, at Palm Springs, California. This represented the single known occurrence of the southern yellow bat in the United States.

During January and February 1960, a crew of gardners at the University of Arizona trimmed the dead fronds from the many palms on the campus. In mid-January the crew discovered a bat hanging in the palm fronds. This bat was killed and discarded. Later, when I heard of this, I asked the foreman to save any bats they were able to capture. To date, bats have been sighted five or six times and two have been captured. Both were adult female *Dasypterus ega xanthinus,* and both were hanging in the dead fronds of the Washington fan palm. The first was captured on 26 January, the second on 9 February 1960. Measurements and weights of these two bats (now No. 3641 and 3640 in the Museum, Department of Zoology, University of Arizona) are: Total length 125, 126; tail 55, 50; hind foot 9, 8; ear 16, 15; tragus 10, 9; forearm 47, 48; and weight in grams 13.4, 17.4.

This represents the first record of *Dasypterus ega* from Arizona and the second and third records from the United States. It is probable that, with intensive collecting, it will be found that *Dasypterus* occurs widely throughout southern Arizona and southern California wherever sufficient palm trees are present.—E. Lendell Cockrum, *Dept. of Zoology, Univ. of Arizona, Tucson. Received 25 February 1960.*

NEW UNITED STATES RECORD OF THE MEXICAN BIG-EARED BAT

Known stations of occurrence of the Mexican big-eared bat, *Plecotus* (*Idionycteris*) *phyllotis* (G. M. Allen), are in San Luis Potosi, at Miquihuana, Tamaulipas, and in the Chiricahua Mountains, Cochise Co., Arizona (C. O. Handley, Jr., Proc. U.S. Nat. Mus., 110: 95–246, 1959). On 2 August 1959, we captured two lactating females of this species 28 miles south and 9 miles east of Flagstaff, Coconino Co., Arizona. They were taken in a mist net stretched across a stock tank in a pasture in a yellow pine forest. Taken at this station the same evening were two *Myotis volans,* one *M. thysanodes,* and one *Antrozous pallidus.* This seems to be the northernmost known occurrence of *P. phyllotis,* and the second record station in the United States.

External measurements of the two animals (in mm) are: Total length, 111–111; tail, 48–48; hind foot, 11–11; ear from notch, 40–41; weight in grams, 12.7–12.9. Selected cranial measurements, taken as described by Handley (*loc. cit.*: 98), are: Greatest length of skull, 17.0–17.8; zygomatic breadth, 9.3–9.7; interorbital breadth, 3.9–4.2; maxillary toothrow, 5.4–5.6; postpalatal length, 6.0–6.4; breadth of braincase, 8.5–9.2; depth of braincase, 5.2–5.7; palatal breadth, 6.1–6.6. The specimens are preserved in the University of New Mexico Collection of Vertebrates. Field work resulting in the capture of these animals was financed by the National Science Foundation.—James S. Findley and Clyde J. Jones, *Dept. of Biology, Univ. of New Mexico, Albuquerque. Received 9 November 1959.*

FIRST RECORD OF THE GRAY BAT IN KANSAS

A young of the year, male bat, skin and skull, No. 19-B, Kansas State College, Pittsburg, was obtained in a residential area on Ford Street, Pittsburg, Crawford Co., Kansas, on 29 July 1958, by Bertram Brown, a student at Kansas State College. This specimen has been

identified as *Myotis grisescens* A. H. Howell by comparisons with specimens of that species in the University of Kansas Museum of Natural History. The insertion of the wing membrane on the tarsus, a characteristic of *M. grisescens*, is well exemplified on this specimen. The concolor hairs of the juvenile pelage of No. 19-B clearly differ microscopically from the bicolored hairs of juvenile *Myotis lucifugus* (E. S. Nason, Amer. Midl. Nat., 39: 345–361, 1948), which might be confused with *M. grisescens*. External measurements are as follows: Total length 85; tail vertebrae 34; hind foot 11; ear (from notch) 12.

This species has not been recorded previously from Kansas and no nearer that state than Crystal Cave, Benton Co., Arkansas (J. A. Sealander and H. Young, Proc. Ark. Acad. Sci., 7: 22–23, 1955), approximately 75 miles southward from Pittsburg. Numerous bats of this species have been obtained from several other caves in the Ozarkian habitat of Benton County. The species has been found in Oklahoma, also in cavernous Ozarkian habitat. The nearest Oklahoma record is approximately 112 miles southward from Pittsburg, 5 miles south of the town of Kansas, in Adair Co., Oklahoma (W. F. Blair, Amer. Midl. Nat., 22: 100, 1939). A recorded locality lying southeasterly, only approximately 90 miles distant, is Marble [= Marvel?] Cave, Stone Co., Missouri (G. S. Miller, Jr. and G. M. Allen, U.S. Nat. Museum Bull., 144: 83, 1928). A locality of occurrence to the northeast is Rocheport Cave, Boone, Co., Missouri (M. J. Guthrie, J. Mamm., 14: 15–16, 1933), approximately 150 miles distant.

I am grateful to H. A. Hays, Kansas State College, Pittsburg, for the loan of the specimen for comparison.—CHARLES A. LONG, *Museum of Natural History, Univ. of Kansas, Lawrence.* *Received 16 February 1960.*

ROADRUNNER PREYS ON A BAT

In the process of examining the stomach contents of some roadrunners (*Geococcyx californianus*), the remains of a red bat, *Lasiurus borealis*, were discovered in a specimen collected 12 September 1959, 0.6 mile north of Odem, San Patricio County, Texas. The bat is now specimen No. 131 in the mammal collection of the Welder Wildlife Foundation. Records of bat predators have been summarized by R. B. Eads *et al.* (Public Health Reports, 70: 995–1000, 1955) and include such birds as owls and hawks. Roadrunners are omnivorous and have been shown to eat birds and small terrestrial mammals (Sutton *in* Bent, Bull. U.S. Nat. Mus., 176: 36–51, 1940), but to our knowledge there is no published record of a roadrunner eating a bat.

Red bats are normally solitary, spending the day hanging in trees. The roadrunner, a strictly diurnal bird, may have found the bat in a low tree or may have discovered it moribund on the ground.

Interest in bats and their predators has greatly increased recently because of their role in the transmission of rabies. However, birds are not considered to play a significant role in the natural history of rabies. In fact, they seem definitely refractory to experimental infection. No bird tested for rabies in the Texas Department of Health Laboratories has been shown to be positive and we know of only one published record of the recovery of rabies from a bird, in this case a vulture (Paarman, Z. Hyg. Infectionskr., 141: 103–109, 1955).

We wish to thank R. B. Eads of the Texas Department of Health for the information on bird rabies and C. O. Handley, Jr. of the U.S. National Museum, for verifying our identification of the bat.—B. J. WILKS AND H. E. LAUGHLIN, *Welder Wildlife Foundation, Sinton, Texas.* *Received 16 December 1959.*

[Contribution No. 46 of the Welder Wildlife Foundation.]

COLOR VARIATION IN BORNEAN GRAY GIBBONS

Uniformity in coloration is a character that has figured prominently in distinguishing the gray gibbon, *Hylobates moloch*, from related species, and the gradation of gray has been utilized in separating four Bornean subspecies of this gibbon. Thus, in October 1959, the authors were interested to observe that gibbon troops in the Lungmanis region, Colony of North Borneo, usually contained members representing considerable range in color.

One troop of six individuals included an exceedingly dark female in which the back and limbs as well as the underparts, customarily dark in the Bornean forms, were nearly black. All that we could see of the infant that clung to her abdomen was colored pale gray. Another member of the same troop was fully as light-colored on the back as the Javan subspecies, *H. m. leuciscus*, although the hue was more buffy than the typical silver-gray of the Javan form. The under surface of the light-colored Bornean adult was smoky brown.

Roughly 200 gibbons were encountered in the Lungmanis area. Troop size varied from 3 to 9 and averaged between 5 and 6. Of the total seen, perhaps one-sixth of the gibbons were notably darker than the smoke-gray that is considered typical of *H. m. funereus*, the alleged North Bornean form, and about the same number were conspicuously lighter. All light-colored individuals possessed the customary dark pileum, light brow band, and dark underparts.

Our observations lead us to doubt that coloration can be used as a diagnostic character to separate the gray gibbons in North Borneo from those of other parts of the island.—KEN STOTT, JR. AND C. JACKSON SELSOR, *National History Museum, San Diego, California. Received 8 March 1960.*

POTENTIAL LIFE SPAN OF COTTONTAILS

The average longevity of a wild species under natural conditions is obviously shorter than its potential life span when protected from natural enemies and disease.

In the early summer of 1959, the author released to the press a request for baby rabbits, *Sylvilagus floridanus*. The story explained that rabbits were needed for a growth-rate study and included a statement that the oldest rabbit in the author's pens was 30 months old. This elicited letters from several readers who had kept cottontails for more than 30 months. From these letters were compiled the following data on the age and location of eight cottontails kept as pets: 40 months, now dead, Kinderhook, New York; 45 months, still alive, Clarkston, Washington; 48 months, now dead, Nelson, Illinois; 54 months, still alive, Chicago, Illinois; 6 years, still alive, San Diego, California (*S. bachmani*); 7 years, now dead, Hagerstown, Maryland; 9 years, now dead, Columbus, Ohio; 9 years and 9 months, still alive, New London, Ohio. This suggests that the potential life span of the cottontail is at least 10 years.—REXFORD D. LORD, JR., *Illinois Natural History Survey and Dept. of Conservation, Urbana. Received 27 January 1960.*

NEW OBSERVATIONS OF INDIANA SWAMP RABBITS

On 9 January 1959, an adult male swamp rabbit, *Sylvilagus aquaticus*, was collected by Conservation Officer Joseph Backer and myself in Sec. 17, T.8 S, R.6 W, Spencer County, Indiana. Its measurements were: Total length, 501; tail, 59; hind foot, 108; ear from notch, 73 mm; weight, 4 pounds 13 ounces. According to Backer and other local hunters, the eastern extent of the range of this species in Spencer County, and presumably in Indiana, is ½ mile east of the woods where this specimen was collected. This point is approximately 50 air miles east of the only other Indiana locality from which, according to the literature, swamp rabbit specimens have been collected. Harrison and Hickie (J. Mamm., 12: 319–320, 1931) record the collection of four Posey County specimens in the extreme southwestern tip of the state.

An adult swamp rabbit was observed in the late afternoon of 1 September 1959, in Sec. 22, T.7 S, R.8 W, Warrick County, Indiana. Unfortunately, it escaped before I could collect it. This locality is south of Yankeetown and was previously reported as the easternmost point in Indiana where the swamp rabbit might be found (Harrison and Hickie, *op. cit.*; Lyon, Amer. Midl. Nat., 17: 295, 1936). Yankeetown is approximately 14 miles northwest of the place where the Spencer County specimen was taken.

The collection of this rabbit in Spencer County does not indicate that it has recently extended its range to this area, as it has occurred here at least as long as local hunters can remember.—RALPH D. KIRKPATRICK, *Biology Dept., Taylor Univ., Upland, Indiana.* *Received 4 February 1960.*

FREQUENCY OF MELANISM IN THE GOLDEN-MANTLED MARMOT

Melanism was believed by Howell (N. Amer. Fauna 37: 1–80, 1915) to be absent in *Marmota flaviventris*. However, Fryxell (J. Mamm., 9: 336–337, 1928) reported black marmots in two areas of the Teton Range. Four cases of melanism were found on the eastern slope between Teton Pass and the Grand Teton and three cases were found on the slopes of the Grand Teton.

As part of a larger study of the social behavior and ecology of the golden-mantled marmot, *M. f. nosophora*, carried on at the Jackson Hole Biological Research Station, it was possible to gather more data on the frequency of melanism in this subspecies. Park service personnel and other biologists at the JHBRS were questioned concerning black marmots. Their reports indicated that melanistic phases ranged from the Bechler area of southwestern Yellowstone National Park (Gunzel, personal communication) to the Snake River Canyon south of Hoback, Wyoming (L. Floyd Clarke, personal communication) and that the black forms centered on the Teton Range. Inquiries of other Yellowstone National Park personnel indicated that melanistic animals had never been seen except in the Bechler area. In the six summers, 1949–1954, that the author spent in Yellowstone National Park, he never saw a black marmot.

It was not possible to personally verify every report of black marmots. However, many areas in the Teton Range were examined and the findings are summarized in Table 1. Those animals that were completely black except for a white or tan patch on the face were considered as melanistic.

TABLE 1.—*Marmots observed in the Teton Range, Wyoming, in areas where melanism occurred*

Locality	Date	Number of melanistic animals	Number of normal animals
Garnet Canyon	3 Aug. 1956	4	9
Death Canyon	12 Aug. 1956	1	2
	16 Aug. 1957	1	1
N. Cascade Canyon	15 July 1956*	4	9
	" " "	5	13
	15 Aug. 1957	4	16
S. Cascade Canyon	15 Aug. 1957	1	4
Skyline Trail	15 Aug. 1957	1	1
Alaska Basin	15 Aug. 1957	2	14
Signal Mountain	18 Aug. 1957	1	2
Jenny Lake	22 June 1955	2	14
	Total	26	85

* Two surveys were made on this date. Since the areas in the canyon overlapped in part, the counts are recorded separately.

The counts, except for Garnet Canyon, Signal Mountain and Jenny Lake, were made during short visits to or while hiking through the area. Since there is no reason to suppose that black marmots are more active than brown marmots, the two color phases should be seen in the same proportion that they occur, provided a large enough sample is tested. On the average, in those colonies that contained melanistic individuals, about one-fourth of the marmots were melanistic. In addition, nine of the "normal" animals had large areas of the body that were black. These areas were usually either the head and shoulders or the rump, back and sides. More accurate counts were made at the head of Garnet Canyon, on Signal Mountain and at Jenny Lake. The proportion of melanistic forms departed markedly from the average at Garnet Canyon and Jenny Lake. The Jenny Lake colony was located at an old CCC Camp and was probably populated by animals that moved in from higher elevations. More brown than black animals may have reached here by chance, hence the higher proportion of brown animals. But Garnet Canyon is fairly well isolated and the population there probably reflects a long-term endogenous development as there probably is little, if any, exchange of individuals between widespread colonies of marmots. There is thus an implication that the melanistic phase may be advantageous in certain environments, or that it may have become locally common through genetic drift. A long-range study of the genetics of coat color and the physiology of the animals would seem to be indicated. The author wishes to acknowledge financial aid from the New York Zoological Society and the Gans Fund, Bethany College, West Virginia.—Kenneth B. Armitage, *Dept. of Zoology, Univ. of Kansas, Lawrence.* *Received 30 December 1959.*

FOX SQUIRREL ATTACKS MOURNING DOVE

At noon on 8 August 1959, in a residential district of Denver, Colorado, I watched an adult female fox squirrel, *Sciurus niger,* as it foraged on a lawn across the street. Leaving the lawn, it leisurely climbed a large American elm and disappeared among the leaves.

Suddenly there was a loud flapping of wings and I looked up to see a small cloud of feathers drifting in the air and debris falling toward the ground. The squirrel was sitting erect on a large limb and looking alertly at a mourning dove, *Zenaidura macroura,* that was flying to an adjacent tree. The squirrel promptly jumped about a foot to an adjoining limb and carefully examined a dove's nest which I had not previously seen. After a quick examination of the nest, it reared on its hind feet as though looking for the dove.

I watched with binoculars as the squirrel worked its way down the tree to the sidewalk where it started to feed. Shortly it sat up holding part of a white eggshell from which it licked the contents. After a few minutes of feeding, it retired to an adjoining tree and preened its face and fore paws.

Examination of the sidewalk where the squirrel had been feeding showed the remains of two slightly incubated dove's eggs. It was obvious that the eggs had been knocked from the nest by the sudden departure of the dove when it was seized by the squirrel.

I watched the dove for about 15 minutes as it sat in the tree to which it had flown. It ruffled its feathers occasionally and sat quietly the remainder of the time. Its only injury seemed to be the loss of 30 or 40 feathers.

The squirrel's unhesitating examination of the nest gave the impression that likely this was not the first time it had looked for eggs in a nest after flushing a sitting bird.—Adrey E. Borell, *U. S. Soil Conservation Service, Denver, Colorado.* *Received 20 January 1960.*

OCCURRENCE OF OS CLITORIDIS IN *MICROTUS*

Among the Rodentia, an os clitoridis has been reported in at least 15 different genera. The purpose of this paper is to report, for the first time, the occurrence of this bone in the genus *Microtus.*

The clitorides of 20 *Microtus californicus*, 2 *Microtus longicaudus* and 4 *Microtus montanus* were removed from freshly killed or recently preserved mice and placed in 10 per cent formalin for a period of 3 or 4 days. The bits of tissue were then macerated and stained simultaneously in a solution of 4 per cent potassium hydroxide–.001 per cent Alizarin Red S for 6 to 10 days, dehydrated by increasing concentrations of ethanol, cleared through two changes of toluene, embedded in piccolyte in plastic deep-cells mounted on standard microscope slides and covered with a cover-glass. Any osseous tissue present was evident as a scarlet-stained area in the transparent flesh. The completed mounts were examined by means of a 100× compound microscope and a 24× binocular dissection microscope. Measurements were taken with an ocular micrometer mounted in the dissection microscope.

The *Microtus californicus* series consisted of 6 wild-caught animals of unknown age and 12 captive-born animals from 5 to 56 days of age. Two other mice were taken in the field when about 2 days old and raised by a foster mother in the laboratory. The six wild-caught specimens, which included four of the mothers of the captive-born litters, were taken in the vicinity of Berkeley, Alameda County and Orinda, Contra Costa County, California. The foster litter was taken near Richmond, Contra Costa County, California. The two *Microtus longicaudus* and the four *Microtus montanus* were all wild-caught and of unknown age, although none appeared juvenile. The specimens of these two species were taken at Sagehen Creek Experimental Station, Nevada County, California.

Traces of an os clitoridis were found in only 2 of the 20 *Microtus californicus*. Both of these were born in capitivity. In one, a 15-day-old animal with parents from Orinda, the bone was club-shaped and measured .57 mm. long by .06 mm. wide with the expanded proximal end being .14 mm. thick (Fig. 1, A). In the female litter-mates of this animal, killed at five and ten days respectively, there was no trace of an os clitoridis. The bacula of two male litter-mates five and ten days old measured .93 by .29 mm. and 1.50 by .57 mm., respectively. Unfortunately, the mother of this litter was one of two female parents whose clitorides were not preserved for study.

The second os clitoridis from *Microtus californicus* was found in a 56-day-old animal with parents from Berkeley. The bone was a mere fragment, measuring approximately .05 by .05 mm. Neither of the two female litter-mates, killed at 36 and 45 days of age, nor the mother, possessed any sign of ossification in the clitoris.

An os clitoridis was found in one of the two *Microtus longicaudus* examined. The structure was generally rod-shaped with each end slightly expanded, but only the distal half was ossified. The proximal half was cartilaginous. The total length of bone and cartilage was .73 mm., the diameter of the larger, ossified end .16 mm., and the diameter of the cartilaginous end .12 mm. The narrow central portion averaged about .08 mm. in diameter (Fig. 1, B).

All of the bones described above were situated anterodorsal to the urethra and lay well within the connective tissue of the clitoris. The two "long" clitoris bones lay roughly parallel to the urethra, much as does the baculum in males.

It seems that the presence of the os clitoridis in *Microtus californicus* is not dependent

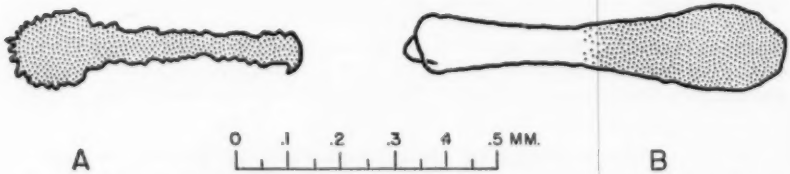

FIG. 1.—The os clitoridis in *Microtus*: A, *M. californicus*; B, *M. longicaudus*. Figures are in dorsal aspect with proximal ends to left. The clear area represents cartilage. Drawn with the aid of a camera lucida.

upon the age of the animal. Also, this bone may be present in only one of the members of the same litter. The fact that the two bones found in *M. californicus* were so different in shape indicates the os clitoridis may not be as uniform as is the baculum of the males of this and several other species of mammals.

The sporadic occurrence of the os clitoridis in *Microtus* seems to parallel the situation found in *Tamiasciurus*, as described by Layne (J. Mamm., 33: 457–459, 1952). He recorded the bone in only 4 out of 13 specimens examined. However, in seven other genera of sciurids he found remarkable uniformity both in the presence and general appearance of the bone, although in a few specimens the structure was entirely cartilaginous (Layne, J. Mamm., 35: 357–366, 1954). In the present study, it is possible that such cartilaginous formations may have been overlooked, although a special search was made for them. Further work utilizing a cartilage-staining technique would be desirable.

It is difficult to relate environmental and nutritional factors to the formation of an os clitoridis, since the two known-age mice possessing a clitoris bone were raised under the same laboratory conditions as others which did not have such a bone, and the female parents of the five captive-born litters were all taken as pregnant animals during a two-month period from two rather limited localities. All of the *longicaudus* and *montanus* were taken during a nine-day period from an equally small area.

The single os clitoridis found in *Microtus longicaudus* demonstrates that this bone may occur in wild-caught *Microtus*. Too few specimens of *longicaudus* and *montanus* were examined to justify any further conclusions concerning these two species.—ALAN C. ZIEGLER, *Museum of Vertebrate Zoology, Univ. of California, Berkeley.* *Received 1 February 1960.*

HIBERNATION IN *PEROGNATHUS FLAVESCENS*

Two female plains pocket mice, *Perognathus flavescens*, were obtained from near Kadoka, South Dakota, and held in captivity for about 18 months. During this time it was noted that they were always active when the temperature was between 20 and 25°C. When the temperatures in the animal room fell to between 10 and 15°C, for several days at a time, one of the individuals was usually lethargic and the other occasionally so.

These pocket mice were placed in constant-temperature cabinets and held at 15, 10 and 5°C. When held in the 15 and 10° cabinets, one or the other was occasionally found in a lethargic condition. When held at 5°C, one mouse went into a deep torpor within 12 hours while the other behaved as it did when held at 10 or 15°C for about 72 hours, after which it was observed in a deep torpor.

Instruments were not available for taking body temperatures of these tiny mice, but they were cold to the touch and appeared to have body temperatures not much above that of their environment while in the torpid condition. When placed in a warm room they became active in about an hour.—JAMES R. BEER, *Univ. of Minnesota, St. Paul.* *Received 8 March 1960.*

[Paper No. 4340 Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.]

THE ENTEPICONDYLAR FORAMEN AND *OCHROTOMYS*

Situated on the medial margin and near the distal head of the humerus, the entepicondylar foramen serves to conduct small blood vessels and the median nerve of the brachial plexus. This small opening in the bone, sometimes regarded as a defect of ossification, was characteristic of the early reptiles and occurs still in *Sphenodon* and in various mammals. Its presence and function were discussed by Landry (1958), who noted that "the foramen may not occur consistently among all the members of the same species." More recently, the presence of this foramen in 21 species of *Peromyscus* was reported by Rinker (1960), who found it present in all of 182 specimens examined except four *P. nuttalli*.

Following Rinker's suggestion, I examined materials in the collections of the U.S. National Museum for the presence of this character. Usable skeletal materials were available from only 96 specimens, representing four subgenera and eleven species. Examples of the fifth subgenus, *Megadontomys*, were not included. The entepicondylar foramen was absent in five specimens of *Peromyscus* (*Ochrotomys*) *nuttalli*. It was present in the other specimens, as follows: *P. floridanus*, 3; *P. boylei*, 2; *P. gossypinus*, 1; *P. leucopus*, 9; *P. maniculatus*, 51; *P. polionotus*, 5; *P. sitkensis*, 1; *P. truei*, 3; *P. crinitus*, 5; *P. eremicus*, 8.

My findings parallel closely those of Rinker, with the notable exception of three specimens, classified as *Peromyscus leucopus*, which lack the entepicondylar foramen. These three are skeletons only, collected in Clarke County, Virginia, by Dr. C. B. R. Kennerly. They were catalogued by S. F. Baird on 26 April 1856. Clarke County, near the northern tip of Virginia, is beyond the range of *P. nuttalli* as presently understood; however, it is only about 115 miles north of Amelia Court House, Amelia County, the type locality of *Peromyscus nuttalli lewisi* Howell (1939), and somewhat closer to Bosher's Dam on the James River, Chesterfield County, where this species was recorded by Goodpaster and Hoffmeister (1954). The possibility of misidentification of these three specimens cannot be altogether discounted. They are not in the best of shape; two of them are juvenile specimens; all are noticeably smaller than typical *Peromyscus nuttalli*. Yet when compared with *P. leucopus*, these three differ in having relatively wider cheek teeth, molars in which the dentine spaces are less confluent, and posterior palatine foramina which are closer to the margin of the interpterygoid fossa than to the anterior palatine foramina—characters typically associated with *nuttalli*.

In his early and classic revision of this group, Osgood (1909: 223) stated: "It is rather surprising that the numerous characters of *P. nuttalli* [the golden mouse] have not been accorded more than specific rank. It differs widely from all other species of the genus in external, cranial, and dental characters." Blair (1942) pointed out peculiarities in the baculum, suggesting that *P. nuttalli* merited generic status. On the basis of the male genitalia, Hooper (1958) concluded that *nuttalli* "resembles species of other genera more closely than any species of *Peromyscus* yet examined. . . . I have additional data, yet unpublished, which further indicate that the hiatus in kinship between *nuttalli* and the other species is a long one, longer than usually can be spanned by a single generic term . . . it is clear that *nuttalli* should be removed from *Peromyscus* and should be listed as *Ochrotomys nuttalli* (Harlan)."

The evidence herein adds further confirmation to the view that *Peromyscus nuttalli*, the sole member of the subgenus *Ochrotomys*, deserves recognition as generically distinct.—Richard H. Manville.

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TWO NEW DISTRIBUTIONAL RECORDS FROM THRACE

During the past two years, I have been collecting mammals in various parts of Turkey for the purpose of studying taxonomy and distribution. Following are two examples of our lack of knowledge of the distribution of common small mammals in this part of the world.

Arvicola terrestris, vole rat.—My attention to this species was attracted by piles of sedge leaves (*Carex* sp.) and the pith of rushes (*Juncus* sp.) on hummocks in a swampy portion of Ali bey Dere (creek) about 4 km. west of Kemerburgaz, Istanbul. Animals were caught with Conibear traps baited with carrot. This species is probably found in Thrace wherever permanent sources of water and adequate food supplies are available.

TABLE 1.—*External and cranial measurements (in mm) of Arvicola terrestris*

Field No.	Locality	Date (1960)	Head and body length	Tail length	Hind foot with claw	Ear from notch	Condylo-basal length
1045 ♀	Kağithane Dere	27 March	184	106*	37	17	38.6
1046 ♂	"	28	186	125	37	16	—
1049 ♂	Ali Bey Dere	29	179	124	37	17	39.9
1050 ♀	"	29	184	119	38	16	39.7
1051 ♂	"	29	203	128	39	19	41.3
1053 ♂	"	2 April	185	128	38	17	40.0
1056 ♂	"	2	203	132	38	18	41.8

* Portion of tail missing.

The measurements of specimens collected in the vicinity of Kemerburgaz are listed in Table 1. The skulls of these animals showed no indication of fossorial modification. Figure 1 (left) illustrates the discrepancy between the known range of this species as illustrated by van den Brink (DIE SÄUGETIERE EUROPAS, Paul Parey, Hamburg-Berlin, 1956) and the author's collections.

Apodemus agrarius, striped field mouse.—This species has been collected in lowlands bordering streams under blackberry bushes and other dense vegetation and in cutover hard-

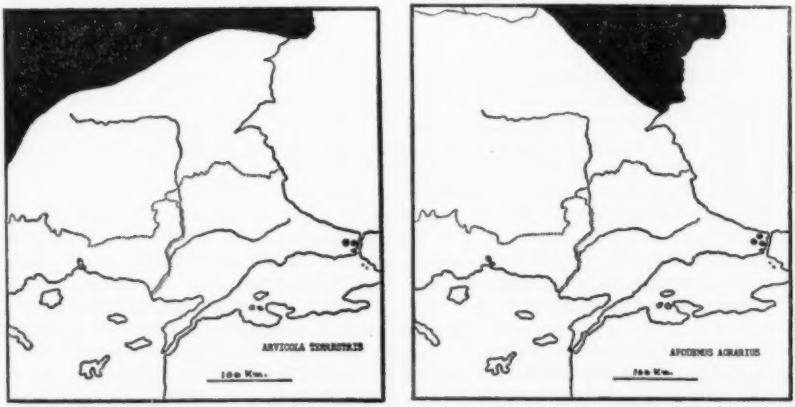

FIG. 1.—The known limits of distribution in southeastern Europe (in black) and the recent collections (dots) of *Arvicola terrestris* (left) and *Apodemus agrarius* (right) in Thrace.

TABLE 2.—*External measurements (in mm) of Apodemus agrarius*

Field No.	Locality	Date	Head and body length	Tail length	Foot incl. claw	Ear from notch
732 ♀	Neşet Suyu (spring)	7 Apr. 1959	89	80	22	13
737 ♀	"	8	101	76	22	13
739 ♀	"	8	107	84	23	12
740 ♂	"	8	115	87	23	13
747 ♀	"	10	109	92	23	13
966 ♂	Kömürcü Bendi (reservoir)	29 Nov. 1960	106	82	21	12
978 ♀	"	30	110	92	23	13
980 ♂	"	30	105	93	23	13

wood forest (coppice) in the Belgrad Forest, and in adjacent areas north of Istanbul. One specimen was trapped in the chaparral disclimax about halfway between Pirinççi and Kemerburgaz. In the latter location, and in the coppice, water would be lacking during the dry summer. According to van den Brink, damp soil is a requisite of this species.

The external measurements of two samples from the Belgrad Forest are given in Table 2. The accompanying map (Fig. 1, right) shows the southern limits of the known range of this species in Europe and the sites where it has been collected by the author. Van den Brink remarked that this species was "Wahrscheinlich im Rückgang." This hardly seems to be the case in this area.

I wish to thank the National Science Foundation, Washington, D. C., for financial aid; Bay Kemal Günen, Director of the Belgrad Forest, for allowing me to trap in a protected area; and Herr Helmut Kownatski for his able assistance in the field.—DALE J. OSBORN, *Dept. of Biology, Texas Technological College, Lubbock.* *Received 7 June 1960.*

TRAP AND BAIT PREFERENCES OF COTTON RATS

Many investigators have shown that the efficiency of estimating population parameters may depend upon the type of trap or bait used, trap spacing, meterological conditions, size of sample plot, and the number of traps used. Since these factors probably vary for different species and also for different densities of the same species, it is advisable to determine the efficiency of traps and trapping pattern before beginning an investigation of population ecology. In this note are reported some of the results of a preliminary study of trapping methods on the cotton rat, *Sigmodon hispidus*.

The study of trapping methods was carried out in a large abandoned field, near Athens, Georgia, in October 1958 and 1959. The field had been vacant for about 8 years and the vegetation was largely purpletop (*Tridens flavus*) and *Lespedeza* sp. These plants formed a dense cover over the ground and provided suitable habitat for cotton rats. Traps were set in a grid, with 10 lines of 10 stations, spaced 10 meters apart. A Sherman live trap, a Victor rat trap, and a Victor mouse trap were placed at each station in 1958. All live traps were baited with chicken-scratch grain and the snap traps were baited alternately with chicken-scratch and peanut butter. In all, there were 666 live traps, 462 rat traps, and 348 mouse traps with grain bait, and 348 rat traps and 396 mouse traps with peanut butter bait available during the trapping period of 6 days. In the first test, 1958, approximately 5 grams of powdered DDT were added to 100 grams of peanut butter to discourage ants from eating the bait. In the second test, 1959, only snap traps were used and these were alter-

nately baited with DDT-treated and untreated peanut butter. In each year, the snap-trapping was preceded by 8 days of live-trapping.

Using the techniques described above, the following questions were tested: (1) Is there a difference in success of live traps, rat traps and mouse traps for capturing cotton rats? (2) Are more rats captured by using grain or peanut butter bait? (3) Does adding DDT to peanut butter reduce captures of cotton rats?

TABLE 1.—*Number and percentage of successful traps*

	Live trap		Rat trap		Mouse trap		All snap traps	
	No.	%	No.	%	No.	%	No.	%
All captures	43	6.5	40	4.9	41	5.5	–	–
New captures	20	3.1	32	4.0	30	4.1	–	–
Grain	43	6.5	24	5.2	27	7.8	–	–
Peanut butter, DDT	–	–	16	4.6	14	3.5	37	3.5
Peanut butter, plain	–	–	–	–	–	–	47	4.5

The data are shown in Table 1. There was no significant difference between type of trap used (X^2 value 3.20, *d.f.* 5) when all captures and only new captures (those not taken in live traps the preceding week) were considered. There is a slight tendency for live traps to recapture mice previously live-trapped. Although these data show that all traps are equally effective, the mouse trap is almost too small for adult cotton rats. Many adults killed by mouse traps pulled out of the trap and were found dead a few feet away.

There was also no significant difference between grain and peanut butter baits (X^2 value 1.00, *d.f.* 3) when rat and mouse traps were considered together. Finally, there was no significant difference between traps baited with DDT-treated or untreated peanut butter (X^2 value 1.19, *d.f.* 1).

This research was supported by a grant from the U.S. Atomic Energy Commission (Contract At[07-2]-10).—FRANK B. GOLLEY, *AEC, Savannah River Project, Univ. of Georgia, Athens.* *Received 2 December 1959.*

NOTES ON THE PACIFIC STRIPED PORPOISE

On 11 September 1958, a fisherman found a dead porpoise floating about a mile west of Trinidad Head, Humboldt County, California. Trinidad Head is located at 41° 03′ N and 124° 09′ W. The porpoise was sent to Humboldt State College where it was identified as a young female Pacific striped porpoise, *Lagenorhynchus obliquidens*.

The cause of death was gluttony. The stomach and esophagus were completely filled with sauries (*Cololabis saria*). In addition, the porpoise had attempted to swallow a 13-inch scad (*Decapterus polyaspis*). The esophagus being full, the scad could not be completely swallowed; the scute-like spinous scales on the caudal peduncle prevented it from being regurgitated. Consequently the porpoise choked to death. Robert T. Orr reported a similar incident in *Phocaena*. (J. Mamm., 18: 370, 1937).

The ovaries were stained, sectioned, and examined microscopically. No corpora lutea were present. The Graafian follicles were well developed, indicating the animal to be nearly sexually mature. It measured 171 cm from snout to tail notch; maximum girth was 106 cm and the weight was 137 pounds. It had 29 pairs of teeth in the upper jaw and 28 in the lower.—WARREN J. HOUCK, *Humboldt State College, Arcata, California.* *Received 16 November 1959.*

GRAY WHALE OBSERVATIONS

Along the Pacific coast of California, Oregon and Washington where it often migrates close to shore and enters very shallow water in bays and lagoons, the gray whale, *Eschrichtius glaucus*, recently believed to be nearly extinct, is now familiar to more people than any other large whale. At La Jolla, California, viewing gray whales from excursion vessels has become a popular tourist attraction. However, the migratory route of the gray whale in northern waters and its distribution in summer is little known. Observations of gray whales made by employees of the Bureau of Commercial Fisheries' Marine Mammal Research office, from research vessels, are made available here to assist in filling in the incomplete parts of the distribution pattern.

Observations off Washington.—Gray whales in northward migration were sighted off the Washington coast, 24 and 25 April 1959, by the U. S. Fish and Wildlife Service charter vessel M/V "Tacoma."

On 24 April, a few gray whales were seen off Cape Johnson (47° 58′ N; 124° 41′ W). One of the lookouts aboard the vessel reported an object breaking and partially clearing the water about 7 miles west of Cape Johnson. Upon investigation, the object proved to be a dead gray whale. The whale was in a bloated condition, the penis and penis sheath had been extruded, and the intestines had been forced from the body and were floating separately about 50 feet distant from it.

During the afternoon of 24 April, over 200 gray whales were seen between Destruction Island (47° 40′ N; 124° 29′ W) and James Island (47° 54′ N; 124° 39′ W), a distance of 15 miles. The whales were in water 20–50 fathoms in depth and were about 5–15 miles offshore. They were observed in singles, pairs and groups of 3–4. The general movement was northerly although, when observed, some were resting and others were feeding and playing. One whale was observed near a 2 × 12 in. plank. The whale came up near the plank several times and either hit or held it with its flipper.

On 25 April, the vessel ran directly offshore from the anchorage at James Island. Gray whales were seen to the north and south of the course and were numerous from the buoy at a depth of 20 fathoms out to about 9 miles offshore at a depth of 50 fathoms.

Observations off Alaska.—Ichihara (Sci. Repts. Whales Res. Inst., 13: 201–205, 1958), in reporting three groups of gray whales consisting of 2, about 20, and about 150 individuals seen west and north of St. Lawrence Island in August 1955, proposed a migration route for the gray whale which entered the eastern Aleutian passes and crossed the central Bering Sea. This was considerably east of the route proposed by Gilmore (Sci. Amer., 192: 62–67, 1955).

On 11 May 1957, eight gray whales in scattered pairs were seen moving toward Narrow Cape between Kodiak and Ugak Islands. The whales were in very close to the kelp beds along Kodiak Islands. The location of these whales suggests that their migration route might lead past the islands off the Alaska Peninsula and follow the route into the Bering Sea proposed by Ichihara (*op. cit.*).

From the Exploratory Fisheries vessel "John N. Cobb," engaged in biological investigations, on 10 August 1959, at 67° 10′ N and 166° 43′ W in the Chukchi Sea, an estimated 100 gray whales were seen feeding over several square miles of ocean. The water depth was about 24 fathoms. The whales made a large muddy blotch in the water as they came to the surface to blow. It seems apparent that in feeding along the bottom the whales gathered mud along with food and were expelling it through their baleen as they rose to the surface. The sticky, clay mud making up the bottom of much of the eastern Chukchi Sea is difficult to wash out. Although the short, coarsely fringed baleen of the gray whale is well adapted for sifting mud from food items, it would be of interest to know if the gray whale swallows some mud along with its food. According to Arseniev and Zenkovich (*in* Kleinenberg and Makarov, Trans. USSR Inst. Fish. & Oceanog., Moscow, 1955) gray whales feed on bottom-living amphipods in the Chukchi Sea. No direction of movement

was evident in this group of whales; they were headed in various directions as they rose to the surface.

On 16 August, observers on the University of Washington oceanographic vessel "Brown Bear" observed about 100 gray whales at 67° 25′ N and 167° 06′ W, feeding in the same manner as described above.

On 19 August, two gray whales were seen from the "John N. Cobb" feeding near 67° 40′ N and 167° 12′ W; and on 20 August, three others, also feeding, were seen at 67° 57′ N and 168° 02′ W. On 29 August, about 20 gray whales, widely scattered and traveling generally southward, were observed at 67° 18′ N and 166° 30′ W. Some of the whales in this group were moving in pairs. None of the muddy water areas associated with feeding was noticed.

Surface-water temperatures ranged from 46.2 to 49°F where whales were observed feeding. Bottom temperatures were 37 to 38°F.

Northern phalaropes (*Lobipes lobatus*), kittiwakes (*Rissa tridactyla*) and arctic terns (*Sterna paradisaea*) followed the feeding whales, settling into the muddy spots where the whales had come to the surface. Whales observed on 19 and 20 August were accompanied by slender-billed shearwaters (*Puffinus tenuirostris*) as well as the birds listed above.

A gray whale, 43 feet in length, had drifted ashore at Cape Thompson in early August. Two others were reported on the beach in the vicinity. On 29 August, a dead gray whale was found drifting about 50 miles west of Kivalina village. It was not greatly bloated. The cause of death of these whales is unknown.—Ford Wilke and Clifford H. Fiscus, *Bureau of Commercial Fisheries, Fish and Wildlife Service, Seattle 15, Washington.* *Received 8 December 1959.*

PECULIAR ACTIONS OF COYOTE AND KIT FOX

Ray Goe, Deputy Sheriff of Inyo County, California, told me of a strange happening at the scene of an auto accident in Death Valley on the night of 10 January 1960. After the victims were removed by ambulance, on the Daylight Pass road at about 1,000 feet elvation, Goe waited in his own car with the lights on the wreckage. At about 2 AM, three kit foxes, *Vulpes macrotis*, approached the scene and inspected the upturned auto. They entered the auto and began to lick blood from the frame. This continued for about 15 minutes. Suddenly, all three animals turned and ran from the scene. No sooner had they left than a coyote, *Canis latrans*, approached; it too entered the auto and licked blood. The coyote was frightened away soon afterward.

There seemed to be a real desire, on the part of both animals, to obtain fresh blood. Although rare in the United States today, the kit fox is relatively common in Death Valley. It is an inquisitive mammal and its curiosity often brings it into campgrounds, where it is fed by the equally curious campers. The coyote, on the other hand, is normally very shy and cautious. The fact that he ventured into a fully lighted auto, only minutes after it had been occupied, seems of interest.—Roland H. Wauer, *Death Valley National Monument, Death Valley, California.* *Received 14 March 1960.*

THE LENS AS AN INDICATOR OF AGE IN THE GRAY FOX

The use of the lens to determine the age of cottontail rabbits, *Sylvilagus floridanus*, has been described by Lord (J. Wildl. Mgt., 23: 358–360, 1959). This same technique has been applied to the gray fox, *Urocyon cinereoargenteus floridanus*. Briefly, it is based on the constant growth of the lens of the eye throughout life. The eye of each animal is removed whole and preserved in 10 per cent formalin to harden the lens. The lens is then removed and dried in an oven. The weight of the dried lens is indicative of the age of the animal. Individual variation in the growth rate of the lens within a species is usually slight.

During the summer and fall of 1955, 112 gray foxes were trapped and killed on three

TABLE 1.—*The dry weight of lenses of 74 gray foxes*

Estimated age in months	Mean weight of lens (mg.)	Range	Number of foxes
3	81.1	81.1	1
4	92.4	89.2– 95.9	3
5	110.0	98.0–119.4	9
6	131.0	129.0–133.1	2
7	138.9	128.8–152.1	33
8	139.6	136.7–142.6	2
9	147.6	142.3–155.3	12
15	170.6	160.3–180.9	2
18	168.7	168.7	1
19	180.3	174.6–186.1	2
21	186.0	170.4–201.7	2
27	202.0	201.9–202.2	2
28	196.8	192.3–199.3	3

study areas in the vicinity of Tallahassee, Florida. The eyes of 104 foxes were removed and preserved in 10 per cent formalin and later were processed to determine the dry weights of the lenses.

Sixty-two of the 104 foxes were juveniles according to weight, pelage, primary and secondary reproductive organs and the tooth-wear technique (Wood, J. Mamm., 39: 74–86, 1958). Five foxes were 1 year old as determined by recapture from the previous year, when their age was estimated as above. Seven foxes probably were 2 years old as determined by recapture from the previous year, when their age was estimated by the tooth-wear technique. Table 1 lists the estimated age and mean weight of the dried lenses of these 74 foxes. Figure 1 is the growth rate curve of the lens of the gray fox based on the data in Table 1.

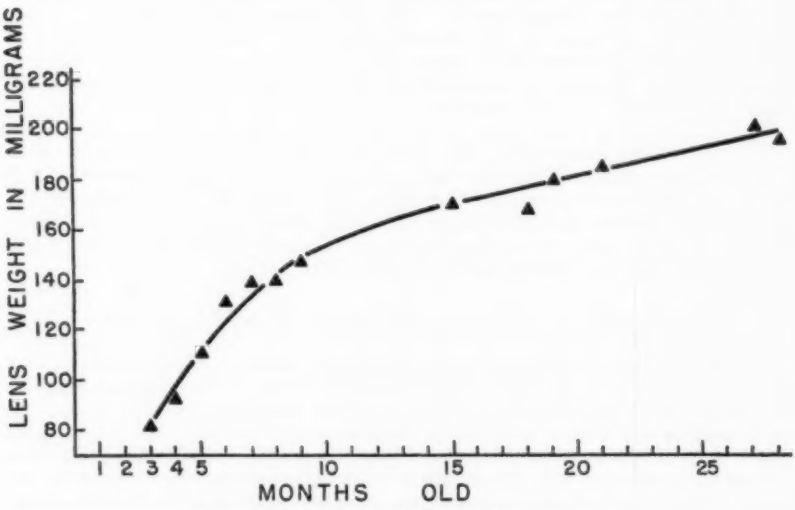

FIG. 1.—Growth curve of the lens of the gray fox.

Using the curve of Fig. 1 as the indicator of the age of the 104 foxes, there was a 78 per cent agreement between the lens and the tooth-wear techniques when both were used to estimate the year of birth of the foxes. Most of the discrepancy was in the older age categories. In 20 out of 21 cases where the age was in disagreement, the tooth-wear technique indicated the age to be greater than did the lens technique. There was a 90 per cent agreement between the two methods when they were used simply to distinguish between juvenile and adult foxes.—REXFORD D. LORD, JR., *Illinois Natural History Survey and Dept. of Conservation, Urbana.* *Received 27 November 1959.*

CURIOSITY OF A MARTEN

Among the rarer mustelids such as marten, *Martes americana*, and fisher, *M. pennanti*, sight records revealing curiosity behavior are uncommon. Grinnell *et al.* (Fur-bearing mammals of California, Vol. 1: 196, 1937) state that there are "very few records of persons having met with [marten] in the wild." Contributing causes are the general scarcity of these species, occurrence in more remote areas, and possibly inherent shyness. However, Hubbard (J. Mamm., 24: 268–269, 1943) gave an account of a fisher seemingly showing unconcern in the near presence of man until the animal apparently caught his scent. Also revealing are Marshall's observations (J. For., 49: 899–905, 1951) on curiosity of the marten in relation to trap susceptibility. He noted Idaho trappers making sets conspicuous to attract the animal's attention. Seton (Life histories of northern game animals, Vol. 2: 917–918, 1909) recorded instances of whistling or walking around a tree as methods used to draw marten into gun view from treetops or dens. Recent interest in the marten as a fur-bearing game animal has provided additional information on this aspect of behavior. Yeager and Remington (J. Mamm., 37: 521–524, 1956) discussed 66 chance observations, among which "curiosity" or "wary, but unalarmed" behavior were mentioned.

A marten I observed on 8 September 1958 provides elaboration on the extent of this curiosity. The sighting was made at 5:00 PM on Black Mesa of the Gunnison National Forest in western Colorado. The temperature was about 60°F and the sky heavily overcast. Elevation at this point is 10,300 feet. While collecting mourning doves (*Zenaidura macroura*) for food-habits information, my path took me from a mixed grass-forb parkland into the edge of a mature Engelmann spruce–subalpine fir (*Picea engelmannii–Abies lasiocarpa*) stand.

Moving very slowly, I caught sight of a marten walking along a fallen tree about 40 feet ahead. I immediately halted. The marten saw me at this time but did not hesitate. It turned in my direction and came rapidly forward, gliding from the fallen tree to the trunk of a large standing spruce 20 feet from me. The animal once circled the trunk low, continually watching me, then descended to the ground and reappeared on the trunk of a second tree 11 feet to my left. For the following 2 minutes it scrutinized me carefully as it moved about in the thickly interlaced lower branches. The closest intervening distance between us was 8 feet, and at no time was the marten over 6 feet from the ground. It appeared of adult size and the orange throat patch was obvious. Ears were constantly erect but no anger was evident. Alert and curious watchfulness describe its movements and actions. Several times the marten emitted a low, throaty chucking sound. Grinnell *et al.* (*op. cit.*) believed marten ordinarily to be silent in the wild, though trapped animals do scream. Seton (*op. cit.*: 910–911) mentioned a variety of sounds associated with marten in capitivity.

When it could approach me no closer without leaving the branches and coming to the ground, the animal started moving back in the same manner. It circled the trunk of the closer tree once or twice, then moved to the first large spruce. Again it circled the trunk, watching me sometimes from a head-down position, sometimes with only the head showing from behind the trunk. I moved closer at this point. My movement triggered the marten which leaped lightly back to the fallen tree where first seen and, with graceful bounds,

moved across several windfalls and disappeared. About 8 minutes elapsed between initial and terminal sightings. The marten's agility, described by Grinnell *et al.* (*op. cit.*: 191) as a "striking air of lightness . . . ," was obvious in all movements of the observed animal.—Curtis H. Halvorson, *U.S. Fish and Wildlife Service, Missoula, Montana. Received 28 October 1959.*

NOTES ON BEHAVIOR OF MARTEN

The preceding comments of Halvorson (J. Mamm., 42: 111, 1961) on behavior of the marten, *Martes americana*, in Colorado recall an experience of mine with this species in the Many Glacier section of Glacier National Park, Montana. Several times a week, with parties of tourists, I visited the area of Cataract Creek, where the stream flows down from Hidden Falls to merge with the outlet of Grinnell Lake. The site is at an elevation of 5,050 feet, heavily forested with Engelmann spruce, Douglas fir and alpine fir. The area remains snowbound well into July. It is frequented by red squirrels (*Tamiasciurus hudsonicus*), porcupines (*Erethizon dorsatum*), black bears (*Ursus americanus*), mule deer (*Odocoileus hemionus*), and such birds as blue grouse (*Dendrogapus obscurus*), water ouzels (*Cinclus mexicanus*), winter wrens (*Troglodytes troglodytes*) and varied thrushes (*Ixoreus naevius*). My notes of 16 August 1954—a cool, rainy day—record a fine view, at 11:00 AM, of a marten that "scuttled along the trail across the creek. It disappeared in the brush and, as I approached, watching in the thick conifers above, it reappeared, still on the ground, moving slowly but stealthily and apparently oblivious of me. It passed me on the trail, not 10 feet distant, did not even start when I squeaked at it, but proceeded leisurely about its business, disappeared briefly behind some willows, then crossed the footbridge and went on out of sight."

Bailey (Wild Animals of Glacier National Park, 1918, p. 89), speaking of martens in this same general area, stated that they "are expert climbers, and if seen at all in the woods are most likely to be seen in the trees. . . . Martens are as a rule unsuspicious and easily caught." Lechleitner (Mammals of Glacier National Park, 1955, p. 32) reports that "they often forage along the forest floor. . . . When startled they often climb quickly into the lower branches of the nearest tree where they will hiss, growl or snarl at the intruder." In the Adirondack region of New York the creature behaves similarly; Hamilton (J. Mamm., 39: 589–591, 1958) remarks that it is an animal easily trapped, and without suspicion.

The marten I observed was decidedly unsuspicious and fearless; it showed no inclination to retreat into the trees, nor did it utter any sound. From some safe shelter it had probably become accustomed to frequent visitation by humans. This appears to be one more instance of a wilderness creature, which we customarily (though perhaps mistakenly) regard as secretive and timid, becoming adapted to living in close proximity to man when afforded protection from hunting, trapping and molestation.—Richard H. Manville, *U.S. Fish and Wildlife Service, Washington 25, D.C. Received 19 November 1959.*

OCCURRENCE OF "SAMSON" CONDITION IN MARTEN

During November 1958, trapper Al Lysher caught, near Mile 23 on the Elliot Highway in interior Alaska (147° 55′ W; 65° 10′ N), a marten, *Martes americana*, which had no guard hairs except at the tip of its tail, the entire pelage consisting of only the soft underfur. A red fox in this condition is called a Samson fox and is relatively common, but to my knowledge this condition has not been recorded for marten or other furbearers. It is probable that this may occur occasionally but, as pelts of this type have no market value, they are probably discarded by the trappers and no records exist. However, it was unknown to Lysher and several other prominent trappers of interior Alaska. The pelt of this marten has been incorporated into the collection of the University of Alaska Museum as No. UA4382.—Wilbur L. Libby, *Spednic Lake, Vanceboro, Maine. Received 11 February 1960.*

RECORD OF AN EXTENSIVE MOVEMENT BY A RACCOON

Most literature on the raccoon, *Procyon lotor*, indicates a fairly restricted home range for members of this species. This note is to record a movement of about 165 miles, between 1952 and 1955, as determined by the return of a tagged animal.

During the summer of 1952, intensive live-trapping for mink was carried out by the author on the Mud Lake National Waterfowl Refuge which lies about 14 miles east of the town of Holt in Marshall County, Minnesota. Twenty-four raccoons were captured, ear-tagged, and released incidentally to the mink study. Among these was a young male weighing 4 pounds 10 ounces which was released on 15 July 1952, at a point .75 mile northwest of the refuge headquarters, with tag No. 171.

Nearly three years later, on 24 April 1955, this animal was trapped by Nels Carlson of Great Falls, Manitoba, in a beaver set on the tributary of the Maskwa River about 20 miles northeast of Great Falls, Manitoba. Mr. Carlson turned the tag over to personnel of the Manitoba Game and Fisheries Branch. This location is approximately 165 miles due north of the release site. No other tags from raccoons taken that summer have been returned.

This record is reported because there is evidence of increasing numbers of raccoons in southern Manitoba; these may be due in part to other similar cases. There is no reason to suspect an artificial movement of this individual.—Fred W. Priewert, *State Game Dept., Belle Fourche, South Dakota. Received 30 November 1959.*

THE MONK SEAL IN FLORIDA

Records of living monk seals, *Monachus tropicalis*, in Florida waters appear to be limited to the southern extremity of the state–Dry Tortugas, Key West and Cape Florida (Moore, Amer. Midl. Nat., 49: 118, 1953). The species has been identified on the central east coast of Florida from Pleistocene deposits at Melbourne, Brevard County (28° 05′ N), on the basis of the proximal phalanx of the right hallux (Ray, Mus. Comp. Zool. Bull., 119: 439, 1958); and from an Indian midden near Lake Hellen Blazes, Brevard County (28° N), on the basis of a fragmentary right mandibular ramus (Rouse, Yale Univ. Publ. Anthropology, 44: 83, 1951; Neill, Florida Wildlife, 10: 16, 1957).

The monk seal is here recorded from the west coast of the peninsula at St. Petersburg, Pinellas County (27° 48′ N) on the basis of a left maxilla with P^2 and P^3 in place. The specimen was found, along with Indian artifacts, on the surface of dredgings on the east shore of Long Bayou (SW ¼ Sec. 1, T.31 S, R.15 E). Although the bone is undoubtedly of Quaternary origin, there is no basis for a more precise statement of its age.

The evidence from Florida, together with sight records from Texas (Gunter, J. Mamm., 28: 289, 1947) and a fossil record probably from the vicinity of Charleston, South Carolina (Ray, *loc cit.*, 441), suggests that the monk seal frequented the entire coast of southeastern United States during Quaternary time. Remains should be looked for in coastal Indian middens throughout this region.

I wish to thank Miss Sheila Most of St. Petersburg for permission to report upon the above specimen, which is in her collection. The assistance of S. J. Olsen and W. T. Neill, who called my attention to the specimens from St. Petersburg and Lake Hellen Blazes, respectively, is gratefully acknowledged.—Clayton E. Ray, *Dept. of Biology and Florida State Museum, Univ. of Florida, Gainesville. Received 4 January 1960.*

BIRTH OF AN ELEPHANT SEAL ON THE TASMANIAN COAST

In the early morning of 21 October 1958, the proprietress of a shop in the small Tasmanian west coast port of Strahan discovered a large seal giving birth on the sidewalk outside her doorway. The pup was born safely tail first and the two seals moved into the roadway where, guarded by red lamps at night time, they obstructed traffic for several days. In

order to reach the place of birth the cow seal must have clambered from the water up an almost vertical embankment 3 feet high, crossed a railroad track, found a gap 3 feet wide in a wire-netting fence, crossed a road and proceeded about 50 yards along the sidewalk. Strahan itself is at the head of the almost landlocked Macquarie Harbor. The cow stayed with the pup, suckling it until both were moved near the shore, where she spent some time in the water. The young seal also frequented rushes in shallow water. Both animals were subjected to almost continuous interference, almost all of it well meant, but undoubtedly deleterious to the normal feeding routine. After ten days the pup died of unknown causes and a day or so later the cow disappeared.

Unfortunately, due to a misunderstood telephone conversation, it was sometime afterward that, while watching a Cinema newsreel, I became aware that the animals were not the local *Arctocephalus* fur seal but a large phocid, almost certainly the southern elephant seal, *Mirounga leonina*. Later, from colored and black-and-white photographs kindly loaned by H. J. Maguire, I was able to confirm this identification and R. M. Laws, of the National Institute of Oceanography, Surrey, England, kindly checked from a photograph sent to him. In his opinion the adult was a typical multiparous cow as judged particularly by scars visible on the body. The cow was measured by reliable local observers as roughly 8½ feet in length. I was unable later to trace the body of the pup.

Although the elephant seal bred on King Island in Bass Strait until the early years of the nineteenth century and single male animals appear to come up on Tasmanian beaches in many, if not most, winters, the nearest breeding place is now Macquarie Island, a distance of 900 miles to the southeast. The present record is comparable to a birth reported on the South African coast by Kettlewell and Rand (Nature, 175: 1000–1001, 1955).—J. L. Davies, *Dept. of Geography, Univ. of Tasmania, Hobart, Australia.* *Received 25 January 1960.*

SYMBOS CONVEXIFRONS AN INVALID SPECIES

Symbos convexifrons Barbour 1934 is known only from the type specimen (University of Nebraska State Museum No. 39001). This sole specimen from the North Branch of the Middle Loup River, Cherry County, Nebraska (U.N.S.M. Coll. Loc. Cr-10) is from the same geologic horizon as at U.N.S.M. Coll. Loc. Cr-102. Both localities are situated in the NW¼, Sec. 18, T.25 N, R.34 W. The geologic age of these deposits is medial Pleistocene, i.e., Illinoian glacial stage. The fossiliferous level is 80 feet above the level of the present stream. Stratigraphically, this level seems to be equivalent to the Crete sand and silt from the Terrace-4 fill (Schultz and Tanner, Bull. Univ. Nebraska St. Mus. 4: 72, 1957). It is therefore of importance to record additional specimens of the genus *Symbos* obtained by parties of the University of Nebraska State Museum from this level at these localities.

During the summer field season of 1958, we found in U.N.S.M. Coll. Loc. Cr-102 the most completely preserved skull (U.N.S.M. No. 39000) of *Symbos cavifrons* known from Nebraska. The specimen is remarkable because the nasal bones are articulated. Immediately below the skull a left M^3, a right M^2, and a right M^1 (U.N.S.M. No. 39000*c*, 39000*d*, and 39000*e*, respectively) were found. These are the first remains of musk ox dentition in the collection of fossil mammals at the University of Nebraska State Museum, which includes 11 skulls of *Symbos cavifrons*.

At the same locality, a right maxilla (U.N.S.M. No. 39000*b*) with PM^3 through M^2 preserved was found during the field season of 1959. Subsequently the anterior suborbital suture of the maxilla was positively articulated with the anterior suborbital suture of the skull found in 1958. In addition, the left M^3 (U.N.S.M. No. 39000*c*) was found to fill the alveolus of the third molar of the maxilla. It is probable that the right M^1 and M^2 described above belong to the same individual. A fragment of a right ramus with P_2 (U.N.S.M. No. 39002) and a left M^3 (U.N.S.M. No. 39003) were also taken from Cr-102 during the 1959 field

season. Previous to 1958 a left radius-ulna (U.N.S.M. No. 39004) and a left metatarsal (U.N.S.M. No. 30431) were collected from Cr-10. These are the only recorded skeletal remains from the area and the state.

These additional remains all belong to the species *S. cavifrons*. Because they are from the same area and collecting horizon as the type specimen of *S. convexifrons*, the validity of this species is questionable. Frick (Bull. Amer. Mus. Nat. Hist. 69: 562, 1937) referred to *S. convexifrons* as a variation of *S. cavifrons*. The convexity between the horncores, the supranuchal ridge, and the internal surface of the cranium are asymmetrical in *S. convexifrons*. These features, when directly compared with the specimens of *S. cavifrons* at hand, seem to be pathological rather than taxonomic variations. Further, because additional remains from this site, or any other site in Nebraska, have yielded only remains of *S. cavifrons*, it seems *S. convexifrons* should not be considered as a valid species.—George E. Jakway, *Univ. of Nebraska State Museum, Lincoln.* *Received 26 February 1960.*

A FAUNA FROM AN INDIAN SITE NEAR REDINGTON, ARIZONA

Members of the Amerind Foundation, under the direction of Dr. Charles C. DiPeso, recently excavated an Indian village site on the San Pedro River, near Redington, Arizona (Davis site, Arizona:BB:11:7). Although the date has not been established, occupancy of the site probably preceded the Spanish contact period. A relatively large mammalian fauna (21 species of wild mammals) is represented in the bone material recovered. Only five species were recorded from the Reeve Ruin Site across the river (DiPeso, The Amerind Foundation, Publ. No. 8, 1958). The reasons for this discrepancy are not clear.

As is to be expected, most of the bone elements represent food animals. Jackrabbits (*Lepus*), cottontails (*Sylvilagus*), and deer (*Odocoileus*) make up the bulk of the material (Table 1). The remainder, each represented by eight or less bone elements, includes 15 species of wild mammals, some of which may be accidentals or intrusions that have little or nothing to do with the particular Indian culture. Pocket mice (*Perognathus*) and kangaroo rats (*Dipodomys*) might fit this category.

The absence of certain kinds of mammals that might have been utilized by the Indians may be of some interest. We do not know whether these kinds were absent in the area at the time, were there but not utilized by the Indians, or whether their remains were not preserved (or found). In this group are: bear, coati, skunks, badger, gray fox, tree squirrels, porcupine, and peccary.

Judging from the remains present, the ecology of the area was probably similar to what we now find there. The whitetail deer and eastern cottontail indicate a wooded area similar to that found on the lower slopes of the adjacent mountains today. Jackrabbits, mule deer, pronghorn, and prairie dog all would indicate open plains conditions that probably prevailed in the San Pedro River Valley. The raccoon and especially the beaver would indicate a continuous flow of water in the river.

From the distributional or zoogeographic point of view, the presence of the ocelot (*Felis pardalis*), and possibly the jaguar, is of some interest. This is near the northern limit of the range of the species and it is now very rare or absent in the area.

If abundance of remains is any indication of abundance of animals, then it would appear that the little whitetail deer (*O. v. couesi*) was much more prevalent than the mule deer (*O. hemionus*); the blacktail jackrabbit (*Lepus californicus*) was more in evidence than the antelope jackrabbit (*Lepus alleni*); and the eastern cottontail (*Sylvilagus floridanus*) more common than the desert cottontail (*S. auduboni*). Further, the implication is that the Indians did considerable hunting in the nearby mountains, as well as in the river valley.

In addition to the mammal remains, there were several bird elements and one frog. The birds, identified by Harrison B. Tordoff, consisted of five kinds of hawks (*Buteo, Parabuteo,*

TABLE 1.—*Identifiable skeletal elements, mostly incomplete*

Species	Skull	Vertebra	Rib	Scapula	Front leg	Pelvis	Hind leg	Foot	Total
*Lepus californicus**	8	5	8	7	21	15	19	10	93
Lepus alleni	9	1				2			12
Lepus sp.	10	11	15	7	8	10	14	12	87
*Sylvilagus floridanus**				2	4		6		12
Sylvilagus sp.*†	1	4	1	8	17	19	36	6	92
*Odocoileus v. couesi**	7	4	3	4	9	1	12	14	54
*Odocoileus hemionus**	1	2			1		1	2	7
Odocoileus sp.	8	14	5	5	5	3	20	31	91
Antilocapra	2				1		1	2	6
Ovis canadensis	4							4	8
Bison?		2							2
Felis (*concolor* or *onca*)								3	3
Felis pardalis	1								1
Lynx rufus					2		1		3
Vulpes				1	1				2
Procyon	1								1
Bassariscus	1								1
Canis (dog?)	10	6			5		7	25	53
Dipodomys sp.						1	2		3
Perognathus sp.	1								1
Citellus sp.	1					1			2
Cynomys sp.							1		1
Neotoma sp.							2		2
Castor	1								1
GRAND TOTAL									538

* Reported from Reeve Ruin.
† Some probably *auduboni*.

Circus, *Accipiter*, and *Falco*), the great horned owl (*Bubo*), raven (*Corvus*), dove (*Zenaidura*), two quail (*Lophortyx* and *Callipepla*), two ducks (*Mareca* and *Mergus*), a goose (*Anser*), and the robbin (*Turdus*). This is a considerably larger assemblage than found in the Reeve Ruin (five species). However, the absence of turkey (*Meleagris*) remains in the Davis Site (present in the Reeve Ruin) is difficult to explain.

The archaeologist is interested in the kinds of wild animals utilized by the particular Indian culture represented, and in the ecological conditions at the time of deposition as indicated by the animal remains. To the biologist, there are also zoogeographic implications and evidence of conditions that prevailed in prehistoric times.

Few zoologists are willing to take the time to identify archaeological material. It is time consuming, and the immediate rewards are not great. However, one never knows when something important will show up. But whether or not one finds something spectacular from a fauna, it is a definite link with the past, a link that we can get in no other way. With the present system of dating organic materials, these remains take on an added significance. They help close the gap between the latest fossil and the earliest historic records.—WILLIAM H. BURT, *Museum of Zoology, Univ. of Michigan, Ann Arbor.* *Received 21 March 1960.*

PREHISTORIC RECORD OF *SCALOPUS* FROM WESTERN PENNSYLVANIA

The eastern mole, *Scalopus aquaticus*, has never been reported from the Appalachian Plateau of western Pennsylvania, although it is found in the eastern Pennsylvania Piedmont and ranges a short distance into the Ridge and Valley Province along the floodplains of the Susquehanna and Juniata Rivers. A trapping program, carried out in western Pennsylvania by the Survey of Pennsylvania Mammals (Richmond and Rosland, 1949; Grimm and Roberts, 1950), captured 67 *Parascalops breweri* and 63 *Condylura cristata*, but no eastern moles. *Scalopus* is the common mole of western and central Ohio, but is replaced by the hairy-tailed mole in eastern Ohio and throughout the Appalachian Plateau.

A left humerus and a partial left mandible of *Scalopus aquaticus* were recovered from excavations at the McKees Rocks Mound Indian site (36A1-16) at McKees Rocks, Allegheny County, Pennsylvania, by William E. Buker and Richard W. Lang of the Society for Pennsylvania Archaeology. The site is multi-component—Archaic, Adena, and Late Prehistoric. In the opinion of Don W. Dragoo, of the Carnegie Museum, the Buker and Lang collections are Late Prehistoric in age, ca.1300–1500 A.D. The site crowns a 60-foot limestone bluff that juts out into the Ohio River at the mouth of Chartiers Creek, 3.5 miles northwest of Pittsburgh. At the time of the Indian occupation, the surrounding area was densely forested, although there probably were cleared areas of limited extent due to Indian agriculture, and grassy areas along the Ohio River's banks.

Associated mammal remains include: *Odocoileus virginianus, Cervus canadensis, Ursus americanus, Canis familiaris, Urocyon cinereoargenteus, Martes pennanti, Mephitis mephitis, Lynx* cf. *rufus, Felis concolor, Sciurus* cf. *niger, Marmota monax, Castor canadensis*, and *Ondatra zibethicus*. The mole remains may not have been contemporaneous with the Indian occupation, but their state of preservation and color were identical with those of the rest of the collection and, while the mole was probably not utilized by the McKees Rocks People, it does appear to have been in temporal association.

The closest modern record in the Ohio Valley is 200 miles downstream, i.e., southwest, from McKees Rocks. *Scalopus* has been taken as close as 75 miles, however, in central Ohio (see Hall and Kelson, 1959, p. 73). The size and massiveness of the specimens (JEG 634, 635) permit them to be referred with confidence to the prairie race, *Scalopus aquaticus machrinus* Rafinesque (Table 1).

There is considerable evidence, derived mainly from biogeographical studies, for former prairie extension(s) into the western Pennsylvania area during the warm, dry, post-glacial climatic episode known as the Xerothermic or Altithermic Period or the Climatic Optimum (Smith, 1957). Smith cites a C-14 dating by Zumberge and Potzger of 4,000 years ago for this period. From 7,000 to 4,000 years ago, the climate was apparently warmer than at any time either before or since, throughout post-Wisconsin times.

TABLE 1.—*Measurements (in mm) of humeri of eastern moles*

Species, locality	GREATEST LENGTH				GREATEST WIDTH			
	No.	Side	Mean	Range	No.	Side	Mean	Range
Scalopus a. aquaticus, Sheep Rock Rockshelter, Huntingdon Co., Penna.	25	R	14.0	13.5–15.5	25	R	11.3	10.0–12.5
Scalopus a. machrinus, Modoc Rockshelter, Randolph Co., Ill.	16	R	16.1	15.5–17.5	16	R	12.5	11.0–13.5
Scalopus a. cf. *machrinus*, McKees Rocks Indian site, Allegheny Co., Penna.	1	L	17.5	—	1	L	13.5	—

The occurrence of the prairie mole as far east as Allegheny County, Pennsylvania, may date from this eastward xerothermic invasion extending up the Ohio River Valley, bringing a Prairie Peninsula biota with it. The McKees Rocks specimens are so late in time, however, that they may represent a relict population, dating from xerothermic times, that was able to maintain itself in a particularly favorable habitat afforded by the floodplain deposits of the Ohio River, perhaps aided inadvertently by the land-clearing activities of these agricultural Indians.

The ecological requirements of *Scalopus* today seem to indicate that the animal was closely restricted to the Ohio River floodplain and avoided the uplands in this highly dissected Appalachian Plateau terrain. Remains of *Parascalops breweri* were recovered from an archaeological site of this same time period in the hill country of Greene County, Pennsylvania, 60 miles south of McKees Rocks in the Monongahela River drainage (Varner site, 36Gr-1).

There is a remote possibility that *Scalopus* may yet be found living in the upper Ohio Valley. The suggestion has been made that the specimens may have been introduced by the Indians as a part of medical or religious regalia, but this too, in view of the common occurrence of adventitious burrowing mammals in Indian refuge material and the lack of any evidence of workmanship or abuse in the specimens, appears remote.

A similar case, the survival to the present day of a xerothermic relict in western Pennsylvania, may be that of the eastern massasauga, *Sistrurus catenatus catenatus*, (Atkinson and Netting, 1927). The widespread distribution of the rice rat, *Oryzomys palustris*, in archaeological sites in southwestern Pennsylvania may be a related phenomenon but, more probably, since it is believed to have led a commensal life in these village areas, its spread to the north was correlated not with any climatic change as such but with the spread of Indian agriculture (Goslin, 1951; Guilday, 1955).

I wish to thank Paul W. Parmalee, Illinois State Museum, for the loan of specimens of the prairie mole, and Neil D. Richmond, John A. Leppla and J. Kenneth Doutt for their assistance.—JOHN E. GUILDAY.

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MAMMAL REMAINS FROM AN ILLINOIS CAVE

On 14 November 1959, the junior authors discovered an opening at the base of the old limestone bluff of the Mississippi River 4 miles southwest of Columbia, Monroe County, Illinois. A narrow, horizontal, 15-foot-long passageway leads from this entrance into a small room, approximately 8 feet high and 8 feet in diameter. There is a narrow oblong hole in the floor that opens into a bell-shaped fissure, the sides of which are smooth and coated with dripstone. The oval-shaped floor (16 × 10 feet) of this vertical fissure is 14 feet below the entrance, and the debris fill is composed of pieces of limestone, soil and bone. Apparently this fissure, like the one recently investigated in Missouri (Parmalee and Jacobson, J. Mamm., 40: 401–405, 1959), served as an efficient death trap for small mammals (as well as numerous snakes, amphibians and a few birds).

Subsequent visits to the cave were made by the authors on 21 November and 19 December 1959, and on 23 January and 20 February 1960. The bone was well preserved, and over 6,000 identifiable remains have been recovered thus far. Twenty-four species of mammals have been identified, with the bones of woodchuck, cottontail, striped skunk, opossum and wood rat being the most numerous and constituting 92 per cent of the total. The quantity of wood rat remains is of interest since it definitely establishes a former population along this portion of the bluff; *Neotoma floridana illinoensis* is presently known only from the river bluffs in Jackson and Union counties, a minimum distance of 50 miles to the southeast.

One of the most noteworthy finds in this cave has been the more than 30 bones of the spotted skunk, *Spilogale* cf. *putorius*. This mustelid is known from Illinois only by archaeological remains found at the Modoc Rock Shelter Site (Parmalee and Hoffmeister, J. Mamm., 38: 261, 1957) in Randolph County, approximately 25 miles south of the cave. The levels in which the *Spilogale* remains occurred at the Archaic Modoc Site have been dated (C14) between 4,500 and 2,500 B.C., but whether some of the cave remains date that early is presently a matter of speculation. However, this second record of the spotted skunk more definitely establishes it as a part of the early faunal complex in southwestern Illinois.

The former range of *Erethizon dorsatum* in the United States was more extensive in early historic times, and there are numerous accounts of the porcupine in regions from which it is now extirpated. In relation to Illinois, several records from Indiana (Lyon, Am. Midl. Nat., 17: 1–384, 1936) are particularly noteworthy. Four Indiana counties in which the porcupine was collected or observed border Illinois and, although this animal probably occurred on the Illinois side of the Wabash and Ohio rivers, records and remains (e.g., from archaeological sites) are wanting. Cory (Publ. Field Mus. Nat. Hist., Zool. Series, 12: 1–105, 1912), with reference to the porcupine, states "I have been unable to find any satisfactory proof of its occurrence in Illinois, although in early days it is not unlikely that it may have inhabited some of the northern counties."

The most significant discovery thus far has been portions of five mandibles, a left premaxilla and maxilla, and lower right M^2 of the porcupine. None of these remains occured together and, although two right and three left mandibles were found, it is difficult to determine if more than three animals are represented. All of the teeth were missing from the maxilla and four of the jaws; a left mandible of an old individual recovered on 19 December 1959 still contained the premolar and all molars, the first two molars showing considerable wear. Porcupines are usually restricted to timbered areas, although the climax vegetation may vary considerably within their range. They appear to be a rather sensitive indicator of forest type and/or climate, but their local distribution may depend upon topography and associated cover, particularly rocky situations such as those provided by the river bluffs. This cave record probably does not indicate an isolated population but rather a southern extension of the porcupine along the Mississippi River bluff in prehistoric (?) times.—Paul W. Parmalee, *Illinois State Museum, Springfield,* Raymond A. Bieri and Robert K. Mohrman, *Belleville, Illinois.* *Received 23 March 1960.*

NOTES ON MAMMALS FROM WESTERN AND SOUTHERN MEXICO

The following notes on distribution and morphology of Mexican mammals are based on specimens contained in the University of Michigan Museum of Zoology. Most of the new records of occurrence are from the coastal sierra of Michoacán, which is the southwestern segment of that state situated south of the Río Tepalcaltepec and east of the ríos Coahuayana and Tuxpan. From a zoogeographical standpoint the region is important, but not until recently have there been serious attempts to sample its fauna. Among late reports on some of its vertebrate species are papers by Peters (Occ. Papers Mus. Zool. Univ. Mich., 554, 1954) and Hooper (*ibid.*, 565, 1955). The mammalian species listed below constitute new records for the region and, in addition, there are new data for other parts of Mexico. The specimens are from the following localities:

Barolosa (Rancho), Michoacán: A ranch, in open pine forests, on the western slopes of the Cerro de Barolosa, about 11 hours by mule east of Coalcomán; probably near 18° 50′, 103° 00′. Specimens were obtained at three stations on the Cerro, each designated by the collector (L. D. Beatty) as muleback time from Rancho Barolosa: (1) 20 min. SW, elevation 7,600 ft.; mature, open, pine forest bordering a natural meadow. (2) 30 min. SW, elevation 7,800 ft.; mature pine and oak forest. (3) 1 hr. 20 min. NE, elevation 8,900 ft.; mature pine and oak forest, the floor with rotting logs and leaf litter.

Carrizo (El), Sinaloa: A ranch that includes a large earthen water "tank" bordered by tall cane-grass (carrizo) located ½ mi. east of the Nogales–Guadalajara Highway (No. 15) and ¼ or ½ mi. south of the Sonora state line in Sinaloa; elevation approximately 50 ft.; mesquite-cactus plains.

Coalcomán, Michoacán: The principal town in the coastal sierra of Michoacán, situated at an elevation of approximately 3,500 ft. in the valley of the Río de Coalcomán; cultivated fields, grassland, riparian forests, and hyacinth-choked ponds on the valley floor; dense brush, thorny trees, and oak on the lower hillsides, giving way to oak and pine at higher elevations.

Dos Aguas, Michoacán: A lumber mill and village located approximately ½ the airline distance between Aguililla and Coalcomán; the collectors listed the locality as 14 mi. W Aguililla, 7,000 ft.; probably near 18° 45′, 102° 57′; principally pine forest; on some slopes the pines intermixed with broadleaf oak, alder and madrone, their trunks and branches draped with lichen, bromeliads and orchids; stands of fir on moist, protected slopes.

Llano de los Flores, Oaxaca: A large, natural meadow, approximately ½ by 1 mi. in extent and 9,200 ft. in elevation, situated about 12 airline miles north of Ixtlán de Juárez on the road that extends from the city of Oaxaca north through Ixtlán and Valle Nacional to Tuxtepec near the Veracruz state line; grass, buttercups, lilies and other herbs on the meadow; mature conifer and oak forests on the surrounding slopes; in some areas, cloud forests of fir, pendant-needle pine, and oak, the trees heavily draped with moss, lichen and other epiphytes.

Ojos de Agua, Michoacán: A settlement near sea level in a small valley at the northern base of the peninsula known as Cabeza Negra or Punta San Juan de Lima, extreme western Michoacán; coquito palms, figs and other large trees on the valley floor; thorny shrubs and trees on the adjoining slopes.

Reparto (Rancho), Michoacán: A ranch on the Cerro Barolosa trail located 6 hrs. 20 min. by mule ESE Coalcomán, in the altitude range 6,000–6,400 ft.; probably near 18° 45′, 103° 03′; open, mature, pine and oak forest, the floor littered with leaves and fallen trees.

Sorex oreopolus ventralis Merriam.—Two specimens from Llano de los Flores, 9,200 ft., Oaxaca, both trapped in the ecotone between a meadow and a wet, mature forest of oak, pine and fir.

These examples provide another locality to the scanty record of occurrence of the species.

Notiosorex crawfordi.—One specimen from El Carrizo, Sinaloa. It was trapped at the base of a mesquite tree, one of several constituting a thicket situated on an open, muddy flat at the base of an earthen dam. Seepage and overflow from the reservoir and ditches

moistened the flat and supported a sparse growth of sedge, salt grass, and a fleshy-leafed plant (probably *Salicornia*).

This apparently is the first record of the species in northwestern Mexico in the region between Mazatlán, Sinaloa, and extreme southern Arizona (Hall and Kelson, Mammals of North America, 1959, p. 65). Zoogeographically, the specimen is referable to the race *N. c. evotis* Coues.

Cryptotis pergracilis.—One specimen trapped under a rotten log in a mature pine forest located at an elevation of 8,900 ft., 1 hr. 20 min. NE Rancho Barolosa, Michoacán.

This adult female resembles examples of *Cryptotis parva* from the eastern United States, and its dimensions fall just below the minima for *C. p. berlandieri* as given by Findley (Univ. Kans. Publ., Mus. Nat. Hist., 7: 615, 1955). Until the shorttail shrews are revised, the name *Cryptotis pergracilis pergracilis* Elliot is applicable to this specimen.

Myotis velifer velifer J. A. Allen.—One specimen shot at dusk in a stand of oak at Rancho Reparto, 6,000 ft., Michoacán.

Eptesicus fuscus miradorensis H. Allen.—One specimen regurgitated by a rattlesnake captured 18 June 1958, at Dos Aguas, 7,000 feet, Michoacán.

Glossophaga soricini leachi Gray.—Seven examples from a cave in a limestone hill at the eastern edge of Coalcomán, Michoacán.

Sciurus poliopus senex Nelson.—Specimens from the following localities in Michoacán: Coalcomán, 3,500 ft., 2; Ojos de Agua, near sea level, 1; Rancho Reparto, 6,000 ft., 1; ½ hr. SW Rancho Barolosa, 7,800 ft., 2; Dos Aguas, 7,000 ft., 23. They were obtained in situations as follows: in tall tropical forest, including figs and coquito palm (Ojos de Agua); in pine–oak forests (Reparto and Dos Aguas) and in broadleaf deciduous forest, many of the trees thorny (Coalcomán).

The specimens from Coalcomán are paler dorsally than those from higher elevations but their worn, ragged pelages are not closely comparable to the long fresh pelages of the other examples. The example from Ojos de Agua is a skull only. Pending revision of the tree squirrels of Mexico, the name *S. p. senex* is applicable to the populations represented here.

Reithrodontomys sumichrasti nerterus Merriam.—Specimens as follows: 20 min. SW Rancho Barolosa, 7,600 ft., 1; 1 hr. 20 min. NE Rancho Barolosa, 8,900 ft., 1; Rancho Reparto, 6,000 ft., 2; Dos Aguas, 7,000 ft., 1. The examples from Barolosa and Reparto were obtained among leaf litter and branch debris on the floor of mature pine–oak forests. The one from Dos Aguas was trapped among grass, herbs, poison ivy and shrubs on a rocky bank of a small stream.

Peromyscus boylei.—Specimens from Michoacán as follows: Rancho Reparto, 6,000 ft., 10; 1 hr. 20 min. NE Rancho Barolosa, 8,900 ft., 2. Dos Aguas, 7,000 ft., 2.

These examples comprise two morphologically distinct lots. Those from Dos Aguas and the station east of Rancho Barolosa differ from those from Reparto in several characters, among which are larger ears, larger auditory bullae, rounded (rather than oblong) brain case, and hourglass-shaped (rather than angular) interorbital constriction. The Reparto series fits with *P. b. evides* Osgood, while the other samples are referable to *P. b. levipes* Merriam. The data derived from these two sets of specimens strongly suggest that in the coastal sierra of Michoacán, as in some other parts of western Mexico (Hooper, Occ. Papers Mus. Zool. Univ. Mich., 565: 15–16, 1955), *evides* and *levipes* behave as full species, reproductively isolated from one another.

Peromyscus lepturus Merriam.—Sixteen specimens from Llano de los Flores, 9,200 ft., Oaxaca.

At this locality, the third record of occurrence of this little-known species, *P. lepturus* was fairly common in the cold cloud forests of fir, pine and oak that border the llano. According to our records it is restricted to the wet, dense, moss-bedecked parts of those forests, where long pendant strands of moss and lichen form lacy curtains in the understory. *P. boylei* and *P. oaxacensis* live in that same habitat, but unlike *lepturus*, they also are

found in open and drier parts of the forests. *P. boylei* is the ubiquitous one of the three species.

Although the three species are superficially similar, the coloration of each being a mixture of black and cinnamon and the three overlapping in size, there are well-marked differences between them, some of which are noted below as a supplement to Osgood's accounts (N. Am. Fauna No. 28, 1909). The following comparisons focus on *P. lepturus*: Pelage longer, apparently denser, and more somber than in either *boylei* or *oaxacensis*; the upperparts with a peculiar grayish woolly appearance such as is seen in *Neotomodon alstoni*. Color and pilosity of tail much as in *oaxacensis*, the hairs clearly shorter than in *boylei*. Duskiness of hind feet variable, extending to the base of the toes in some specimens and confined to the base of the foot in others, but silvery hairs present in both dusky and non-dusky areas. Body size as in *oaxacensis*. Tail, foot and ear dimensions larger than in both that species and *boylei* (see measurements below), but the ratio of ear to foot (.79 in *lepturus*) between that of *boylei* (.89) and of *oaxacensis* (.58). Similar to *oaxacensis* in cranial size, but the interorbital area narrower and less angular, the molar teeth larger both in length and, especially, in width, and the auditory bullae actually and relatively larger.

Following are means (in mm) of 6 specimens of comparable age of *boylei*, *lepturus*, and *oaxacensis*, arranged in that order, from Llano de los Flores: total length, 194, 241, 233; tail vertebrae, 96, 122, 115; hind foot, 22.5, 28, 26; ear from notch, fresh skin, 20, 22, 19; greatest length of skull, 27.9, 30.5, 31.0; zygomatic breadth, 14.0, 15.9, 15.5; length of nasals, 11.3, 12.2, 12.9; interorbital breadth, 4.2, 4.5, 4.8; alveolar length of molar row, 4.5, 5.3, 5.0.

Sigmodon melanotis Bailey.—Seven specimens from Dos Aguas, 7,000 ft., Michoacán, trapped in growths of grass, poison ivy and other shrubs and herbs. All are dark reddish brown dorsally and the underparts and upper sides of the hind feet are deep or light cinnamon.

Sylvilagus floridanus restrictus Nelson.—One specimen shot in a milpa surrounded by open forest of pine, oak, and madrone at Dos Aguas, 7,000 ft., Michoacán.

In coloration and in length of head and body (415 mm), hind foot (96) and ear from notch on fresh skin (62), this specimen agrees with examples of *S. f. restrictus* from the vicinity of Cerro Tancítaro, Michoacán, but its skull is as large (basilar length, 61.9 mm) as crania of *S. cunicularius* from that area of Michoacán.—Emmet T. Hooper, *Museum of Zoology, Univ. of Michigan, Ann Arbor. Received 15 December 1959.*

SMALL MAMMAL RECORDS FROM WESTERN UTAH

Additional collecting, most of it subsequent to a previous report (Shippee and Egoscue, J. Mamm., 39: 275–277, 1958) has extended the known ranges of three mammals to include Tooele County. New locality records for mammals already known or suspected to occur in western Utah also were obtained. Field work was supported in part by U.S. Army Chemical Corps contract DA-18-064-CML-2639, with the University of Utah. J. G. Bittmenn, Jay Linam and Stephen de St. Jeor assisted with the collecting. Specimens mentioned are in the collections of Ecological Research. Unless otherwise noted, all localities are in Tooele County. Measurements are in millimeters.

Sorex vagrans vagrans Baird, vagrant shrew.—This small, rather brightly colored subspecies of the vagrant shrew previously has not been reported from desert valleys of the Bonneville Basin. Specimens from the north end of Skull Valley extend the known area of occurrence approximately 50 miles westward from several localities near Salt Lake City (Findley, Univ. Kans. Publ., Mus. Nat. Hist., 9: 57, 1955). The shrews were secured in tin-can traps baited with grain and set in runways of montane voles (see account of *Microtus montanus nexus*). Measurements of two females and one male are, respectively, as follows: Total length, 100, 100, 102; length of tail, 40, 39, 40; length of hind foot, 13, 12, 12; length of ear from notch, 5, 5, 5. Each female weighed 4.0 grams; the male weighed 3.5 grams. All were in the reddish-brown summer pelage. Although these speci-

mens have shorter tails than topotypes of *S. v. vagrans* described by Findley (*op. cit.*: 52), the series is too small to permit a more detailed analysis.

Specimens examined: Three from Timpie Springs, ½ mile east of Timpie Junction, 4,246 ft.

Sorex palustris navigator (Baird), water shrew.—Six water shrews were collected 30 August 1959 in Ophir Canyon, southwest Oquirrh Mountains, the crestline of which marks the eastern boundary of Tooele County. They were caught in a line of 93 Museum Special traps baited with peanut butter and set at varied intervals for about 900 feet along the edge of Ophir Creek, under overhanging banks or behind waterfalls. Only the upper part of Ophir Creek offered much in the way of suitable habitat for water shrews. A short distance downstream from where the specimens were collected the creek was diverted into a pipeline to provide water for the town of Ophir, leaving the creek bed dry almost to the mouth of the canyon, except where leaks occurred in the pipeline.

These specimens were the first recorded from Tooele County; they extend the known range of this shrew approximately 35 miles southwest from City Creek Canyon, a locality in the Wasatch Mountains a short distance east of Salt Lake City, where Durrant (Univ. Kans. Publ., Mus. Nat. Hist., 6: 37, 1952) recorded many shrews of this species. Although this extension of range is not great in terms of miles, it represents the first locality well within the Bonneville Basin where water shrews are now known to occur.

Measurements of five females (averaged) and one male, respectively, were as follows: Total length, 150, 153; length of tail, 72.2, 72; length of hind foot, 20, 21; length of ear from notch, 5, 5. Females weighed 9.7–12.0 (avg. 11.2) grams; the male weighed 14.9 grams.

Specimens examined: Six, all from Ophir Canyon, 2 miles upstream from Ophir, Oquirrh Mts., elevation about 7,500 feet.

Lasiurus cinereus cinereus (Beauvois), hoary bat.—When Durrant prepared his accounts of bats for the state, there were only about a dozen specimens of the hoary bat known from Utah (*op. cit.*: 56–57), none of which was collected in the west desert area. A female of this species was captured at 4:00 PM on 1 May 1958, about 3 miles north of Iosepa, Skull Valley, by J. E. Stinson. According to Stinson, the bat apparently misjudged its altitude and hit the water as it flew over a small pond; it was unable to resume flight after entering the water.

Sylvilagus nuttalli grangeri (Allen), Nuttall's cottontail.—Although specimens were not available at the time, Durrant (*op. cit.*: 81) rightly included the mountainous sections of both eastern and western margins of Tooele County within the range of this species. R. M. Hansen secured three specimens 3 miles south of Ibapah (unpublished thesis, Univ. of Utah, 1951). Nuttall's cottontails have since been collected from numerous locations in the Stansbury Mountains, Skull Valley and Cedar Mountains, although few were saved as specimens. The ranges of Nuttall's cottontail and the Audubon cottontail frequently overlap in the foothill regions; both species were collected from the same localities at several points in Skull Valley (4,300 to 4,800 feet) where *S. nuttalli* probably nears the lower limits of its altitudinal distribution in the area.

Specimens examined: Four, distributed as follows: Ahlstrom's Mine Canyon, S end Stansbury Mts., 5,850 ft., 1; Johnson's Pass between Stansbury and Onaquai Mts., 1; Round Mt. (= Little Granite Mt.), 1; South Ranch (Deseret Land and Livestock Co.), 5 miles S of Iosepa, Skull Valley, 4,800 ft., 1.

Sylvilagus auduboni ssp., Audubon cottontail.—A specimen collected at the north tip of the Stansbury Mountains about 200 feet south of Highway 40, elevation 4,246 feet, extends the known range of this cottontail approximately 40 miles north of a line drawn east from a locality 1 mile north of Gold Hill in central western Tooele County, Utah (Shippee and Egoscue, *op. cit.*: 275).

Microtus montanus micropus Hall, montane vole.—Habitat suitable for voles is scarce and highly discontinuous at lower elevations in western Utah. Specimens of *M. m.*

micropus collected at Salt Springs (Blue Lake) are believed to be the first examples of this subspecies from northwestern Tooele County. Hansen (*op. cit.*) reported montane voles of this subspecies from 1 mile east of Ibapah in the extreme southwest corner of the county. Thirty-two voles (15 adults, 2 subadults, and 15 juveniles) were trapped during the latter part of April 1959, in runways among rushes (*Scirpus* sp.) and salt grass (*Distichlas stricta*), along the margin of a small pond. Specimens agree closely in color and size with descriptions given by Durrant (*op. cit.*: 367) for this subspecies. The western harvest mouse, *Reithrodontomys megalotis*, was the only other species of mammal collected in vole runways at Salt Springs.

Specimens examined: Total 14, all from Salt Springs (Blue Lake), 20 miles S Wendover, 4,350 ft.

Microtus montanus nexus Hall and Hayward, montane vole.—Specimens collected from two localities in northern Skull Valley provide the westernmost records of occurrence of this subspecies known from the county. At Timpie Springs, voles were abundant in late August and early September 1958, when 30 were collected from a small patch of tall, dense salt grass that formed a canopy 12–14 inches in height over the runways and almost completely screened activities of the voles from above. Other small mammals collected in this trapline were house mice, *Mus musculus*; deer mice, *Peromyscus maniculatus*; western harvest mice, *Reithrodontomys megalotis*; and vagrant shrews, *Sorex vagrans*. The number of species in this assemblage of small mammals contrasted markedly with the number of species captured in vole runways at Salt Springs, as mentioned in the account of *M. m. micropus*.

Specimens examined: Eight, distributed as follows: Timpie Springs, ½ mile east of Timpie Junction, N end of Skull Valley, 4,246 ft., 5; 6 miles S Timpie Junction, 3.

Mus musculus Linnaeus, house mouse.—A feral colony of these mice was discovered in a small marsh at the north end of Skull Valley a few yards south of Highway 40, where house mice and other small mammals were utilizing runways of the montane vole. Fifteen house mice of all age classes were trapped, indicating the species was well established. Human habitations at Timpie Junction, ½ mile west, may have been the source of animals for this small, localized colony of wild house mice.

Zapus princeps utahensis Hall, western jumping mouse.—Although Durrant (*op. cit.*: 388) had four specimens from Butterfield Canyon, a Salt Lake County locality in the northeast Oquirrh Mountains, he did not include the west side of these mountains in Tooele County within the ascribed range of *Z. p. utahensis*.

An adult female and a subadult male were collected along upper Ophir Creek from the same trapline mentioned in the account of *Sorex palustris navigator*. The female was very fat (33.4 gms.), the smaller male had accumulated very little fat and weighed 21.3 grams. Both mice were caught in traps set at the water's edge. Measurements of female and male, respectively, were as follows: total length, 247, 239; length of tail, 152, 149; length of hind foot, 33, 34; length of ear from notch, 16, 14.

Specimens examined: Two, from Ophir Canyon, 2 miles upstream from Ophir, southwest Oquirrh Mts., about 7,500 ft.—HAROLD J. EGOSCUE, *Ecological Research, Univ. of Utah, Dugway.* *Received 21 December 1959.*

[Contribution No. 46 from Ecological Research.]

WILLIAM HARVEY ON THE MATING OF RED DEER

William Harvey's discovery of the circulation of the blood is well known, but his work on embryology and sexual physiology, *De Generatione Animalium* (1651), though important in the history of embryology, is less familiar to zoologists. Most of this book is taken up with studies of the chick and with theoretical speculation, but the last few chapters detail his close observations on the red deer, *Cervus elaphus*. As the King's

physician, Harvey was often present at the deer hunts of Charles I, held almost weekly. Bucks were hunted during the summer, hinds in the fall. Harvey dissected many of these hinds, and his account of their genital anatomy and embryos was a model of conciseness and clarity seldom found in biological works of his time. In contrast to many scholars of that day, he was not above consulting tradesmen when he might learn from them. Some of his information on the mating of the red deer was gleaned from the King's game wardens, though it also included his own observations, excerpts from which are quoted below.

> The hind and doe admit the male at one and only one particular season of the year, namely, in the middle of September, after the Feast of the Holy Cross; and they bring forth after the middle of June, about the Feast of St. John the Baptist (24th June). They, therefore, go with young about nine months, not eight, as Pliny says. . . .
>
> At the rutting season the bucks herd with the does; at other times they keep severally apart, the males, particularly the older ones, associating together, and the females and younger males trooping and feeding in company. The rutting season lasts for a whole month, and it begins later if the weather have been dry, earlier if it have been wet. . . .
>
> At this time deer are rendered savage by desire, so that they will attack both dogs and men, although at other seasons they are so timid and peaceable, and immediately betake themselves to flight on the barking of even the smallest dog.
>
> Every male knows all his own females, nor will he suffer any one of them to wander from his herd: with a run he speedily drives back any straggler; he walks jealously from time to time among his wives; looks circumspectly about him, and the careful guardian of his own, he shows himself the watchful sentinel. If a strange doe commit any offence, he does not pursue her very eagerly, but rather suffers her to get away; but if another buck approach he instantly runs to meet him, and gives him battle with his antlers.
>
> The hind and doe are held among the number of the chaster animals; they suffer the addresses of the male reluctantly, who, like the bull, mounts with violence, and unless forced or tired out, they resist him; which disinclination of the females appears also to be the reason of their herding together, and confining themselves to their own males, who are always the older and better armed; for when any strange male approaches them they immediately take to flight, and seek refuge in their own herd, and protection to their chastity, as it seems, from their proper husband. . . .
>
> Old and sturdy bucks have a considerable number of does in their herds, as many as ten, and even fifteen; younger and weaker males have fewer. Keepers say that the doe is sated with two, or at the most with three leaps; once she has conceived she admits the male no more.
>
> The lust of the male cools when he has served his females; he becomes shyer, and much leaner; he deserts his herd and roams alone, and feeds greedily to repair his wasted strength, nor does he afterwards approach a female for a whole year.

The foregoing account is abstracted from *The Works of William Harvey, M.D.*, translated from the Latin by Robert Willis, London, 1847, pp. 474–476. These observations seem to have mostly escaped the notice of recent workers.—FRANK N. EGERTON, *History of Science Dept., Univ. of Wisconsin, Madison.* *Received 19 January 1960.*

REVIEWS

Bourlière, François, and Jacques Verschuren. INTRODUCTION A L'ECOLOGIE DES ONGULÉS DU PARC NATIONAL ALBERT. Fasc. 1 de Exploration du Parc National Albert. Institut des Parcs Nationaux du Congo Belge, Brussels. 158 pp., 96 figs., 18 tables. 1960.

In 1933, after considerable discussion among the chief colonial powers in Africa, it was agreed that firm action must be taken to prevent the slaughter of the larger African mammals. The British favored the strict control of hunting, while the Germans advocated special sanctuaries, where the habitat as well as the individual animal could be maintained. This latter view prevailed and with the acceptance of the *Convention Relative to the Preservation of Flora and Fauna in their Natural State* the various African powers agreed to set up a series of Parks and Reserves. Such a one was the Albert National Park of the Belgian Congo (Hayden, S. S. 1942. The International Protection of Wildlife. Columbia Univ. Press, N.Y., 246 pp.).

These large areas of protected habitat, withdrawn from human use and patrolled against poaching, proved successful. They came to be islands of the original Africa in a spreading desert of human over-use. More recently, with the accelerating movement toward self-government and the emergence of new nations from colonial rule, the fate of these natural areas has been in doubt. If they are thrown open to unrestricted human use the fate of the wild large mammal populations will be extinction.

The International Union for the Conservation of Nature and Natural Resources, acting for men the world over concerned with the loss of natural communities, has declared this to be the most pressing of all of the many pressing problems in nature conservation. An intensive effort is being made, in concert with FAO and UNESCO, to reach the native leaders now responsible for resource policy, and to make clear to them the value of the things which they, and the world, might lose, and the ways in which they may yet be saved.

Badly needed, at this juncture, is a body of information on the ecology, behavior, physiology and population dynamics of the larger mammals, since these are the most vulnerable to exploitation and habitat change. Fortunately, Africa has been the field of effort of a number of competent investigators, the authors of the work under review among them. The magnitude of the work yet to be done should not blind us to the extreme utility, at the present juncture, of the work already accomplished. Even preliminary results, available at the proper moment, weigh more heavily in the affairs of men than the most complete information produced only after the habitat is gone.

This study was carried out between July 1957 and August 1959, while Albert National Park was still under Belgian administration. The senior author, a distinguished physician and professor on the Faculty of Medicine at the University of Paris, is best known to mammalogists through his comprehensive work on *The Natural History of Mammals* and his activity in the field of international conservation. The junior author has for some years been a biologist attached to the Congo National Parks, and has produced two volumes on the mammals of the Garamba National Park along the Sudan border. At the time that this study began, he was stationed at Albert National Park.

The study was undertaken with the aim of contributing materially to the knowledge of the mammals of Albert Park which, lying as it does near the Uganda border, contains a good representation of African habitats. Support for the study came from the *Institut des Parcs Nationaux du Congo Belge* and Belgian private funds. The facilities of the Park itself, including the use of personnel, were put at the disposal of the authors. There was an excellent union, in short, of first-class investigators with ample facilities.

The present volumes, covering the ungulates, are the first of a series which will treat, in turn, the rodents, insectivores, bats and carnivores. They are dedicated to Victor van Straelen, President of the Institut des Parcs Nationaux du Congo Belge on the occasion of his twenty-fifth year in that position.

Albert National Park has been protected from human interference for over 25 years,

although some fires occur each year. It contains three principal types of habitat: the *open* steppe, savannah and swamp; the *closed* thicket, dry forest and heavy forest (of flat and mountain); and the high-altitude subalpine and alpine. Each of these principal habitat types was stratified into sub-types on the basis of plant physiognomy, for the purpose of establishing census routes and determining the affinities of the various ungulates for specific ecologic situations.

The ungulates found were: the elephant (*Loxodonta africana*); the warthog (*Phacochoerus aethiopicus*); the bush pig (*Potamochoerus porcus*); the forest hog (*Hylochoerus meinertzhageni*); the hippopotamus (*Hippopotamus amphibius*); the water chevrotain (*Hyemoschus aquaticus*); the okapi (*Okapia johnstoni*); the situtunga (*Limnotragus spekii*); the bushbuck (*Tragelaphus scriptus*); the bongo (*Boocerus eurycerus*); the buffalo (*Syncerus caffer*); several duikers (*Cephalophus nigrifrons, C. sylvicultor, C. dorsalis castaneus, C. callipygus, Philantomba monticola, Sylvicapra grimmia*); the waterbuck (*Kobus defassa*); the Uganda kob (*Adenota kob neumanni*); the reedbuck (*Redunca redunca ugandae*); the topi (*Damaliscus korrigum ugandae*); and a dwarf or "royal" antelope (*Hylarnus harrisoni*).

For each of these the numbers, principal habitat affiliations and food habits were investigated. In addition, the total density of combined ungulate populations in each habitat type was determined by means of strip-counts conducted several times a year. Each habitat type was found to have its characteristic species, in varying abundance. For each, by assigning an average live weight for each species, it was possible to calculate the average bio-mass. Thus the savannah samples gave, for 1959, the following values for bio-mass in kilograms per square kilometer: elephant—5,950; hippopotamus—11,200; buffalo—6,150; topi—260; waterbuck—195, altogether totaling, with lesser members of the community, 24,406 kg. per sq. km., one of the highest values observed in Africa to date. Values similarly derived are given for other habitats.

Population fluctuations over the past three decades have apparently occurred at least in the more conspicuous animals, and presumably in the others as well. In general, these can be explained by an increase in woody vegetation due to a lower frequency of fires. This accounts for the long-term diminution of topi and Uganda kob, and the parallel increase in elephant and buffalo. But other factors must also be at work, for the kob and topi have in the last decade begun to increase again.

Among the other data obtained for the ungulates of this region were those for population structure (by sex and age), social organization, season of reproduction, rate of reproduction, and mortality. On the basis of this information the authors believe that populations do not exceed the carrying capacity of their ranges (except for the elephant), and are not generally limited by predation. Rinderpest is a periodic cause of loss in the buffalo, and to a lesser extent in the bushbuck, the warthog and the forest hog. Anthrax affects the hippopotamus.

A cause of mortality peculiar to the neighborhood of active volcanoes in this Park is carbon dioxide, which often causes the death of considerable numbers of ungulates.

Forty-nine plates, bound separately, illustrate the habitats, the species discussed, including predators, and some of the aspects of volcanic activity.

A question which will inevitably occur to the reader of this research report, or of this review, is—what effect will the independence of the Congo have on the natural communities of Albert National Park? An interim answer, at least, has been given by Dr. Bourliére (ltr. 28 Oct. 60): "Despite the political troubles of the last months, the present situation in the Albert Park is rather satisfactory. All the administrative staff left during the few days following independence, but the Park biologist, Jacques Verschuren, chose to stay alone and succeeded in an almost miraculous way in keeping the Park going on. Young Congolese administrators have been appointed by the Congolese government and both scientific activities and tourism are now being resumed. The difficulty will be to find the necessary money. . . ."—Richard D. Taber.

James, W. Warwick. THE JAWS AND TEETH OF PRIMATES. Pitman Medical Publ. Co., London. Pp. xxii + 328, illus. 1960. Price, £5.5.0.

The dental structures are among the most frequently preserved vertebrate features and all mammalogists are well aware of their importance in taxonomy. From their remains as fossils may be determined much of an animal's facial expression and mode of life. Yet, until now, there have been no comprehensive representations of these structures for an entire order.

The author, an octogenarian, made a career of dentistry and surgery, and doubled on the side as an alpinist, cellist and teacher. During World War I, he did pioneer work on the reparative treatment of wounds of the face and jaws. In 1922 he was awarded the John Tomes Prize of the Royal College of Surgeons of England. In 1939, on retiring from a large private and clinical practice, he continued his research on zoological aspects of the jaws and teeth. One histological study concerned the development and structure of dentine. Another related to the arrangement and form of the teeth of vertebrates, one phase of which comprises the present volume.

In a general introductory section are discussions of the anatomical and functional features of the jaws and teeth, and the evolution of these structures in primates. The following systematic section constitutes most of the book. Simpson's classification is followed. For one species of each genus three good photographs are presented: a lateral view with the teeth in near occlusion, and separate views of the upper jaw and the mandible. Nearly all specimens illustrated are in the British Museum (Natural History). The characteristics of each group are briefly discussed, including the special traits of the teeth; distribution is noted; common and scientific names are cited; and there are statements on diet and other matters. Three appendixes treat of individual development of the opposing jaws and teeth; of the articular eminence of the temporo-mandibular joint and its significance; and (surprisingly) of the care of primates in captivity, with interesting longevity records of various species. An extensive bibliography and an index complete this attractive and useful volume.—RICHARD H. MANVILLE.

National Geographic Society. WILD ANIMALS OF NORTH AMERICA. Washington, D.C. 400 pp., 409 illus., 258 in color. October 1960. Price, $7.75.

Many of us grew up on Edward William Nelson's *The Larger* [Nov. 1916] and *The Smaller* [May 1918] *North American Mammals*, with their splendid illustrations by Louis Agassiz Fuertes, in the pages of the National Geographic Magazine. These two issues, long since collectors' items, are now replaced in full measure by the present handsome volume. The illustrations are plentiful and excellent. The text has been brought up to date and thoroughly revised, incorporating many of the articles in the magazine itself as well as much other matter. This is not new material, but a skillful digest of data already published; pertinent information is cleverly fitted into every inch of space available. This is popular nature writing at its best.

Consultant for the book, and contributor of several chapters, is our Past President, A. Remington Kellogg. Other members of our Society who wrote chapters are Victor H. Cahalane, Goode P. Davis, Jr., Donald R. Griffin, Robert M. McClung, Donald A. Spencer, Ernest P. Walker and Stanley P. Young. The 28 chapters are arranged in six major parts concerned with Animals in Fur [an introductory section], the Hoofed Mammals, the Meat Eaters, Gnawing Mammals, Survivors of Ancient Orders, and Ocean Dwellers. A typical chapter has a leading section of general discussion, followed by biographies of the principal species, usually restricted to a page or less. Here are recounted anecdotes and facts of the animals' lives and habits, together with dimensions, range, and characteristics. And these accounts are not simply a rehash of common knowledge, but include recent findings: the birth of twins to hybrid polar × brown bear parents; the navigation of bats by echolocation; the sprinting of pronghorns at 50 mph; the common denning of armadillo, cottontail and rattlesnake; the occurrence of one albino in 50,000 porcupines; the use of

tranquilizers to permit ear-tagging of grizzly bears; the diggings of a ground squirrel leading to discovery of the Comstock Lode; and attempts to obtain an electrocardiogram from a gray whale. Treated are 138 species from the Mexican border to the Arctic.

Only the National Geographic could be so lavish with colored plates and still offer this volume at such a bargain price. Reproduced are the best of the Fuertes plates from the earlier issues; appearing for the first time are 51 paintings and drawings by Walter A. Weber; also represented are Else Bostelmann, André Durenceau, Charles R. Knight, Carl Rungius—and even Beatrix Potter and Currier and Ives. Many photographs, both in color and black and white, as well as line drawings of tracks and other features, supplement the paintings. This is truly the most magnificent volume of the Geographic's *Natural Science Library*.

This book will serve as a useful reference at home or office. It will appeal to young and old, nature lover and sportsman. The pictures are accurate, the text authoritative. The end papers feature an animated map of the continent and a reproduction of Albert Bierstadt's "The Last of the Buffalo." Appended are a five-page index and a list of the principal National Parks and National Wildlife Refuges, serving as sanctuaries for our wildlife, in this and neighboring countries.—RICHARD H. MANVILLE.

Simons, Elwyn L. THE PALEOCENE PANTODONTA. Philadelphia: Trans. Amer. Philos. Soc., N. S., 50 (6): 1–81, 18 figs. Price, $2.50.

The reader will find here a summary of the early history of the study of the pantodonts. The systematic revision recognizes four families and ten genera. The superfamily Coryphodontoidea is erected for the family Coryphodontidae, which includes the genera *Coryphodon, Eudinoceras* and *Hypercoryphodon*. The superfamily Pantolambdoidea includes the families Pantolambdidae, Baryambdidae and Titanoideidae. The genera *Pantolambda* and *Caenolambda* are included in the Pantolambdidae. The family Barylambdidae includes *Barylambda, Haplolambda, Leptolambda* and *Ignatiolambda*. The genus *Titanoides* constitutes the Titanoideidae. One new genus and five new species are described.

It is interesting to note that after nearly 100 years of collecting from the Paleocene deposits of North America, only parts of about 200 pantodonts have been recovered and that almost half of these are either single teeth or small lots of post-cranial bones.

From the scattered collections in North America, the author has been able to assemble the critical data on the dentition, mandible, skull and post-cranial skeleton of the Paleocene species. These have been presented in a well-organized manner for each species.

Following the systematic section there is an excellent discussion of the pantodont skeleton. Individual parts of the known skeleton of each genus are briefly compared with parts known from other genera. It would have added greatly to the value of the paper if more good line drawings had been used in figuring skulls, limb bones and the pelves.

The geologic and geographic distribution of the Old World and North American forms are discussed. A table is given for the North American Paleocene species. For the non-vertebrate paleontologists in North America and for the students in Eurasia that read the paper, a map of western North America, showing the location of the local faunal sites listed in the table, would have been most helpful.

The osteological study has provided some evidence of the adaptive radiation within this early order of mammals. With this information and that of the sedimentary environments where the fossils were recovered, the writer has given his interpretation of the paleoecology of the North American Paleocene genera.—CLAUDE W. HIBBARD.

Terres, John K. THE WONDERS I SEE. J. B. Lippincott Co., Philadelphia. 256 pp., 15 drawings by Walter Ferguson. October 1960. Price, $5.00.

In this attractive volume, John K. Terres—erstwhile naturalist with the Soil Conservation Service, lecturer on wildlife, free-lance writer, and currently Editor of *Audubon Magazine*—tells of the drama in the world about us with entries from his journal spanning a full year. "A naturalist's journal," he writes, "is his treasure house. In it he stores the

intimate experiences with nature that he has every day. . . . Out of these experiences, when written day after day, he sees a continuity that bcomes a spinning wheel of life—a web of life—in which animals, plants, weather, seasons, and climate are bound together in the inexorable forward movement that we call a year. . . . Within this pattern birds and other animals live their complicated lives." He observes with discernment and writes in an engaging style.

The scene shifts from his backyard on Long Island to a distant seashore, from rural New England to a Southern swampland. His subjects range from hibernating toads and mating tree crickets to "anting" starlings and singing trees. Mammals come in for their fair share of attention, with essays or anecdotes of deer and shrews, bears and woodchucks, bobcats and field mice, squirrels and foxes, red bats and cottontails. One gets informative insights into the habits of wild animals and the ways in which a naturalist ferrets out their secrets. One might wish that the date when Peary discovered the North Pole (p. 47) had been checked more carefully!

Before writing this book, Terres turned to his garden "constantly and in fascination because of the unfolding patterns of the lives of the animals that lived there. The generations of squirrels became known to me individually, and I learned to know individual insects and spiders by marking them with harmless dyes, and the birds by banding them. I proved to my satisfaction that the only way really to learn about animals is to study them as individuals. I am convinced that the small game in my backyard—sparrows, woodpeckers, centipedes and others—lead no less interesting lives than a black bear, an antelope or an eagle." Through his stress on the commonplace, casual naturalists and confirmed biologists alike will become more aware of the everyday life about them, more conscious of the common problems and situations that face all living creatures.

A selected list of general and popular references and a brief index are appended.—RICHARD H. MANVILLE.

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COMMENTS AND NEWS

NOTICE OF ANNUAL MEETING

The Forty-first Annual Meeting of the Society will be held at the University of Illinois, Urbana, Illinois, Monday evening, 12 June, through Thursday, 15 June 1961. Registration will begin Monday afternoon, 12 June, in Garner House residence hall. Board of Directors' meeting will convene at 8:30 PM in Room 174, Garner House. An informal pre-convention get-together, with refreshments, will get underway at 9:00 PM in the lobby of Garner House. Regular sessions will begin at 9:30 AM, 13 June, in the auditorium of the Law Building.

Group housing will be provided in Garner House. Sections of this dorm will be set aside for men, for women, and for married couples and families. Rates are $3.00 per night per person in double-room (two single bed) accommodations, including maid service and towels; $4.25 per night per person for single-room accommodations; $1.50 per night for children under 12; no charge for children under 2. Some triple-bed rooms are available. Meals will be served in a central dormitory cafeteria, about 50 yards from Garner House, except for Tuesday, Wednesday, and Thursday dinners. Breakfast, $.75; lunch $1.25; dinner, $1.75, when taken as package for all meals. Otherwise, individual meals are $.25 more. Half-fare meal rates apply for children 2–12. Room and board reservations can be made in advance. It is especially desirable to indicate in advance if you will arrive Monday, 12 June, and if you wish dinner.

Motels and hotels are also available. Prices and distances from the convention headquarters are indicated. Reservations should be made directly to the motel or hotel. HOTELS: Tilden Hall, Champaign, single, $5–6, 1½ miles; Urbana-Lincoln, single, $7–8, 2 miles. MOTELS: Chief Illini, Urbana, $7.50–12, 2 miles; Lincoln Lodge, Urbana, $10–12, 2 miles; Paradise Inn, Champaign, $7–11, 3½ miles; Courtesy Motel, Urbana, $7–10, 2 miles; Studio Lodge, Champaign, $7–10.50, 1 mile.

Camping facilities are not available in Champaign-Urbana. The Twin Lakes camp at Mahomet, 11 miles from Champaign-Urbana, will be available for a limited number of campers.

The University of Illinois is located in Champaign-Urbana, about 120 miles S Chicago, 200 miles ENE St. Louis, 120 miles WNW Indianapolis. It can be reached from Chicago via Ozark Airlines and Illinois Central Railroad; from St. Louis via Ozark and Wabash Railroad; from Detroit via Wabash. Cars marked with "ASM" will pick persons up Monday and Tuesday at the airport and stations. Make yourselves known to the drivers.

Highways into Champaign-Urbana include US 45 south from Chicago, state route 10 connecting with US 66, federal route 74 from Indianapolis, and others. Illinois Central trains arrive in Champaign from Chicago at 9:45 AM, 6:25 PM, 7:00 PM. Wabash trains arrive in Champaign from St. Louis at 11:12 PM, 1:34 PM; from Detroit, 5:17 AM, 2:30 PM. Train times must be verified at a later date. Train times are Central *Standard*. Ozark Airlines arrive in Champaign from Chicago at 9:16 AM, 1:04 PM, 5:45 PM, 10:34 PM; from St. Louis at 7:03 AM, 11:07 AM, 3:00 PM, 5:27 PM; and from Indianapolis at 8:16 PM.

The University of Illinois has an air travel service, consisting of a fleet of passenger planes, which can be made available to A.S.M. members in an emergency. Such planes, on due notice, could pick up convention travelers if stranded at stations or airports as far away as Chicago or St. Louis and could aid them in making proper connections when returning home.

Inquiries concerning housing, camping, and general plans for the Annual Meeting, other than titles for papers, should be directed to Dr. Donald F. Hoffmeister, Museum of Natural History, University of Illinois, Urbana, Illinois.

Titles for papers should be submitted to Dr. Bryan P. Glass, Department of Zoology,

Oklahoma State University, Stillwater, Oklahoma. The deadline is 1 May, but it is suggested that titles, estimates of time, and equipment required be sent in at an early date. Papers to be considered for an honorarium and resolutions proposed for action should be submitted early (see below).

RESOLUTIONS

Members having resolutions intended for action by the Society at its next annual meeting are urged to submit them to the Resolutions Committee at the earliest opportunity. The committee is anxious to submit the proposals to the members prior to the meeting but can do so only if they receive such proposals at an early date. The deadline of 1 May 1961 has been set. Proposed resolutions should be sent to the Committee Chairman, Dr. Keith R. Kelson, National Science Foundation, Washington 25, D.C.

HONORARIA

Two honoraria are available each year for young mammalogists who have not obtained the Ph.D. degree. Each honorarium carries a stipend of $100 to help defray expenses of travel to the annual meeting for the presentation of the paper. The next meeting will be held at the University of Illinois, 12–15 June 1961. Entries should be submitted to Dr. Emmet T. Hooper, Museum of Zoology, University of Michigan, Ann Arbor, before 1 April 1961.

PROPOSED AMENDMENT OF BYLAWS

Article IV Meetings

SEC. 1.

From: An annual stated meeting shall be held in accordance with the action of the Society at the preceding annual meeting. Due notice of such meetings shall be given by the Secretary-Treasurer.

To: An annual stated meeting shall be held in accordance with the action of the Society at the preceding annual meeting. In the event of no decision, the Directors are empowered to act. Also, the Society may plan for meetings more than one year in advance. Due notice of such meetings shall be given by the Secretary-Treasurer.

GENERA OF RECENT MAMMALS OF THE WORLD

This research and writing project is progressing nicely and nearing completion. It is designed for publication in three volumes. Two of the volumes will contain basic information regarding all the genera of Recent mammals and one or more pictures of representative species of each genus. The third volume will contain bibliographic citations classified by subjects. However, many pictures are still needed, especially of small marsupials, small rodents, and bats from most parts of the world except North America and Europe. Better pictures are also desired of many of the Madagascar mammals. Pictures might be acceptable as late as 1 January 1962, or possibly later, but those received late may not be needed because others have been received in the meantime. Persons who have black and white pictures which they are willing to sell and which may be suitable for the project are invited to communicate with Mr. Ernest P. Walker, 3016 Tilden Street, N.W., Washington 8, D.C., U.S.A.

LLEWELLYN MEMORIAL LIBRARY

Our recently deceased member, Leonard M. Llewellyn, was born on 6 December 1907 in Allegany County, Maryland. His formal education at Virginia Polytechnic Institute was completed in 1941, since which time he has been employed by the U.S. Fish and Wildlife Service. He was associated with the U.S. Fur Animal Experiment Station, Saratoga Springs, New York, where he conducted studies on feeding and breeding of fox and mink in captivity. Later he was assigned to study marsh ecology of the muskrat on the Eastern Shore of Maryland. For the past 15 years he has been on the staff at the Patuxent Wildlife Research Center, where he was most recently responsible for field investigations in the agricultural wildlife research program. He is best known for his studies of reproduction of fur animals, biology of the raccoon, and population studies on fur animals.

To perpetuate the memory of Leonard Llewellyn, a number of his friends have established the Llewellyn Library Trust Fund to support the Leonard M. Llewellyn Memorial Library on Fur-bearing Animals. This library will be housed at the Wildlife Unit, Department of Forestry and Wildlife, Virginia Polytechnic Institute, Blacksburg, Virginia, in recognition of his association with that institution. Anyone having books or reprints pertinent to fur-bearing animals may contribute copies to this new collection. Such items should be sent to the Custodian (Henry S. Mosby), Leonard M. Llewellyn Memorial Library, Department of Forestry and Wildlife, V. P. I. Funds are also being solicited for the purchase of new books and support of the collection. Checks should be made out to "Llewellyn Memorial Library Fund" and sent to Dr. Carlton M. Herman, Patuxent Wildlife Research Center, Laurel, Maryland.

NEWSLETTER FOR BAT-BANDERS

Bat Banding News, a quarterly mimeographed newsletter, is now available. The first issue appeared in October 1960. Plans call for the *News* to contain occasional short articles on such subjects as homing, migration, sex ratios, and rabies in bats, as well as notes on banding techniques and problems, methods of catching bats, etc. Interested persons may subscribe by contacting Dr. Wayne H. Davis, Editor, Biology Dept., Middlebury College, Middlebury, Vt. Cost is 50 cents per year.

ALASKA WILDLIFE RANGES

More than a dozen years of controversy terminated in a red-letter day for conservation when, on 6 December 1960, the Secretary of the Interior, Fred A. Seaton, established by administrative action three wildlife areas in Alaska. The Arctic National Wildlife Range of over 14,000 square miles, including parts of the Brooks Range in extreme northeastern Alaska, borders on the Arctic Ocean and on the Yukon Territory. The Kuskokwim National Wildlife Range includes over 2,800 square miles near the delta of the Kuskokwim River. The Izembek National Wildlife Range of 649 square miles is near the tip of the Alaska Peninsula. This action has been repeatedly supported by resolutions of this Society.

AUSTRALIAN MAMMAL SOCIETY

We are advised that the next meeting of the Australian Mammal Society will be held at Brisbane, Queensland, on 26–27 May 1961.

NSF LABORATORY DEVELOPMENT PROGRAM

The National Science Foundation announces that 1 March 1961 is the next closing date for receipt of proposals in the Graduate Laboratory Development Program. Proposals received after 1 March will be reviewed following the next closing date, 1 September 1961. This program requires at least 50 per cent participation by the institution with funds derived from nonfederal sources. Purpose of the grants is to aid institutions of higher education in modernizing, renovating or expanding graduate-level basic research laboratories used by staff members and graduate students. Only those departments with a graduate training program leading to the doctoral degree in science are eligible. Proposals and requests for additional information should be addressed to: Office of Institutional Programs, National Science Foundation, Washington 25, D.C.

RUSSIAN TRANSLATIONS

Under the sponsorship of the National Science Foundation and the Smithsonian Institution, progress has been made by The Israel Program for Scientific Translations. Flerov's *Musk deer and deer* (Vol. 1, No. 2 of FAUNA OF USSR: MAMMALS, Moscow and Leningrad, 1952) is now available in a 257-page English translation, bound, at $2.75 per copy. Orders may be placed through the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. Similar translations are now in preparation of Vols. 1–4 of Ognev's MAMMALS OF USSR AND ADJACENT LANDS.

AIBS TRANSLATION PROGRAM

The American Institute of Biological Sciences is undertaking to expedite the translation of biological publications in exotic languages (Arabic, Chinese, Russian, etc.) if sufficient justification exists. Professional societies are asked to document the needs for publishing translations of particular works. Forms for requesting this service may be secured from Francis C. Harwood, Director of Publications, AIBS, 2000 P Street NW, Washington 6, D.C.

LIVE SPECIMENS FOR RESEARCH

A variety of wild amphibians, reptiles and mammals are available for physiological or behavioral laboratory studies or other purposes. Several dozen species are always in stock, others can be supplied for special needs. For price list, write California Animal Supply Co., P.O. Box 25712, W.L.A. Station, Los Angeles 25.

PERSONAL NOTICES

This space is available to members of the Society for brief notices of interest to mammalogists. Copy should be sent to the Editor by the 10th of the month preceding publication. Rates for single insertion are 25 cents per line or portion thereof. Notices will be continued in each issue unless cancellation is received a month before publication or unless specified in original order. Bills will be rendered by the Secretary-Treasurer following publication.

FOR SALE—Two sets of the *Journal of Mammalogy*, 1919–1933 and 1919–1960, complete. A few numbers slightly damaged by moisture. Stuart Criddle, Treesbank, Manitoba, Canada.

FOR SALE—*Japanese "Mist" Bat Nets.* Send for price list. W. B. Davis, 254 F.E., College Station, Texas.

FOR SALE—Live desert rodents. Send for information and price list. Keith E. Justice, 44 W. Rillito St., Tucson, Arizona.

KEY TO THE SKULLS OF NORTH AMERICAN MAMMALS, by Bryan P. Glass, has been reprinted and may be ordered from the Research Foundation, Oklahoma State University, Stillwater, Oklahoma. Price $2.00 as in the past.

URGENTLY NEEDED—*Serum of foreign pinnipeds* for a comparative study involving electrophoretic and immunologic work on pinnipeds of the world. Directions for preservation and shipping sent on request; we assume shipping costs. Murray L. Johnson, Museum of Natural History, University of Puget Sound, Tacoma 6, Washington, U. S. A.

FOR *Sherman Live Traps* write H. B. Sherman, P.O. Box 683, De Land, Florida.

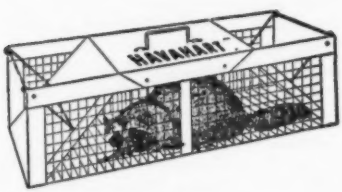
ALL-PETS MAGAZINE is written for hobbyists, breeders, fanciers and people engaged in pets for profit; covers all unusual livestock kept as pets, plus aquaria, cage and aviary birds, cats and dogs; subscription $3.50 per year. Manuscripts solicited from ASM members. Established 25 years, circulation world-wide, 80 pages and up monthly. We also publish books on pet livestock; some 80 titles now. National distributors of some 350 books on pets. Write for free book circular to Frank Dittrich, 139 Darling Place, Fond du Lac, Wisconsin.

WANTED—*Correspondents* anywhere with interest in rodents or other small mammals. Also interested in swapping southwestern U.S. species for those from other areas. Niles H. Hagedorn, 44628 N. Gingham Ave., Lancaster, Calif.

TO AUTHORS

The attention of all contributors is invited to the STYLE MANUAL FOR BIOLOGICAL JOURNALS, recently published by the AIBS. This 100-page manual was prepared, over the past three years, by the Committee on Form and Style of the Conference of Biological Editors. Drafts have been read by approximately 100 editors and publishers, and the recommendations included have been adopted in whole or in part by 76 American biological journals, as an aid in standardizing editorial matters. The *Journal of Mammalogy* is one of these, insisting however that it will retain the abbreviation *J. Mamm.* in citations. Copies of the MANUAL are available, at $3.00 each, from the American Institute of Biological Sciences, 2000 P Street NW, Washington 6, D.C.

HAVAHART HUMANE ANIMAL TRAPS



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